TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Report 30

Transit Scheduling: Basic and Advanced Manuals

Transportation Research Board
National Research Council

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13. ABSTRACT (Maximum 200 words) This manual will be of interest to new transit schedulers, experienced schedulers, transit planners, operating staff, and others who need to be conversant with the scheduling process. The materials clearly describe all steps in the bus and light rail scheduling process. Under TCRP Project A-11, *Transit Scheduling: A Manual with Materials*, research was undertaken by Transportation Management & Design of Solana Beach, California, to prepare a transit scheduling manual that incorporates modern training techniques for bus and light rail transit scheduling. The manual consists of two sections: a basic treatment and an advanced section. The basic-level section is in an instructional format designed primarily for novice schedulers and other transit staff. The advanced section covers more complex scheduling requirements. Each section may be used sequentially or independently and is designed to integrate with agency apprenticeship and on-the-job training.			
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Report 30

Transit Scheduling: Basic and Advanced Manuals

RANDALL PINE
JAMES NIEMEYER
RUSSELL CHISHOLM
Transportation Management & Design
Solana Beach, CA

in association with
Nelson\Nygaard Consulting Associates

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academy of Sciences, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP REPORT 30

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NOTICE

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
Transportation Research Board

This manual will be of interest to new transit schedulers, experienced schedulers, transit planners, operating staff, and others who need to be conversant with the scheduling process. The materials clearly describe all steps in the bus and light rail scheduling process.

Scheduling is a craft, whether executed manually or with computer assistance. New employees of transit scheduling departments need training in this craft to do their job, and experienced schedulers require retraining to fill gaps in their knowledge. The best known reference guide on this topic was issued in 1946; it does not reflect modern information technology or operating conditions. Therefore, a new transit scheduling manual, suitable for use in a training course, was needed by the transit industry.

Under TCRP Project A-11, *Transit Scheduling: A Manual with Materials,* research was undertaken by Transportation Management & Design of Solana Beach, California, to prepare a transit scheduling manual that incorporates modern training techniques for bus and light rail transit scheduling. The manual consists of two sections: a basic treatment and an advanced section. The basic-level section is in an instructional format designed primarily for novice schedulers and other transit staff. The advanced section covers more complex scheduling requirements. Each section may be used sequentially or independently and is designed to integrate with agency apprenticeship and on-the-job training.

To achieve the project objective of producing an updated transit scheduling manual, the researchers conducted a review of literature and existing practices to identify methods used to schedule transit vehicles and personnel; conducted site visits at a cross-section of transit agencies to establish the state of practice; prepared a glossary to define scheduling terminology and identify common synonyms; and developed a manual that outlines the steps in a model scheduling process. These steps include both manual and microcomputer applications using standard commercial spreadsheet software.

The basic-level training section was evaluated at two mid-sized transit systems and at one smaller midwest university. The advanced training section was evaluated at two larger, multimodal transit systems. The findings indicate that the content and design of the manual effectively and efficiently meet a need for practical, structured and documented transit scheduling training materials applicable to both transit and nontransit participants with varying degrees of transit experience and need.

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COOPERATIVE RESEARCH PROGRAMS STAFF

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AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under TCRP Project A-11 by Transportation Management & Design (TMD) in association with Nelson\Nygaard Consulting Associates.

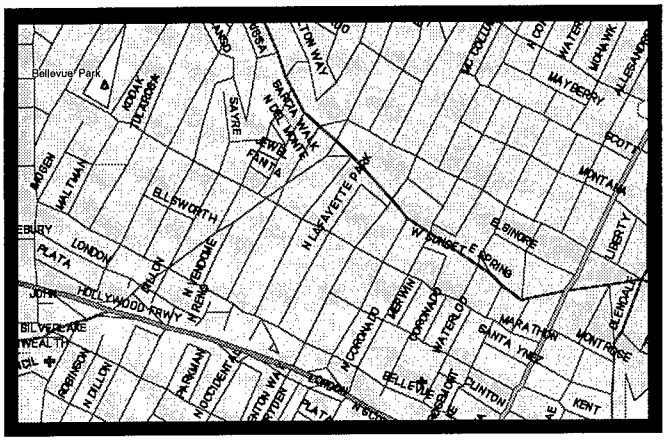
Randall Pine, Senior Associate at TMD was the Principal Investigator. James Niemeyer, also a Senior Associate at TMD, was the Co-Principal Investigator of this project. The work was done under the general supervision of Randall Pine and James Niemeyer. Other members of the research team included David Sharfarz, TMD Senior Researcher; Russell Chisholm, Senior Researcher and Senior Partner at TMD; Susan Law, Researcher at TMD; and Bonnie Nelson, Senior Researcher subcontracting from Nelson\ Nygaard Consulting Associates. Mark Bergstrom, Senior Partner at TMD, acted as Administrative Officer.

TRANSIT SCHEDULING: BASIC MANUAL

CONTENTS

CHAPTER 1

SERVICE POLICIES AND SCHEDULE DEVELOPMENT



STUDY OBJECTIVES

1) Remember that the development of service schedules is heavily influenced by organizational service standards and policies.

2) Understand that service standards and policies are set by board policy and considered management priorities.

3) Be aware that policies and standards used in service development are a balance between cost efficiency and the provision of adequate service to the public.

4) Know that three areas of schedule development most greatly influenced by service standards and policies are 1) route structure, 2) service frequencies and 3) service timing.

5) Learn that route structure defines where the route will go and is related to the interconnectedness of the entire service network.

6) Know also that three areas of route structure include cycle times, route configurations and interlining.

7) Be able to recognize the definitions of route cycle, route configuration and interlining.

8) Understand that maximizing the route length to cycle time utilizes equipment and labor time more efficiently.

9) Recognize how the maintenance of a fixed headway (frequency) can lead to additional layover/ recovery time.

10) Understand how planning for vehicles to arrive at a common location for a timed transfer affects cycle times.

11) Be able to recognize diagrams for branches, loops and short turns.

12) Be knowledgeable of the three types of service frequencies – policy (minimum), demand-based and performance-based frequencies.

13) Remember the four typical service timing standards and policies are 1) transfer connections, 2) trunk intertiming, 3) clock frequencies and 4) service timing hierarchy.

I. Introduction

Within the transit organization, the development of service schedules is heavily influenced by organizational service standards and policies. These standards and policies establish *guidelines* on how service can be developed and scheduled.

II. Service Standards and Policies

Service standards and polices generally are set by board policy and considered management priorities. As such, they tend to vary from one organization to another.

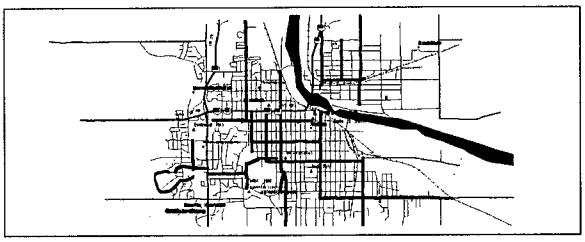
Policies and standards are generally designed to provide a logical balance between optimal cost efficiency and the provision of adequate service to the public.

Three areas of schedule development that are most greatly influenced by service standards and policies are:

1)	Route structure	Where the vehicle travels during the service day
2)	Service frequencies	How often a vehicle comes by on the route
3)	Service timing	When the vehicle comes by on the route

Route structure

Where the vehicle travels on a route during the service day is, to a great degree, related to the interconnectedness of the service network.



The structure of individual routes and how they interconnect with other routes are part of route structure.

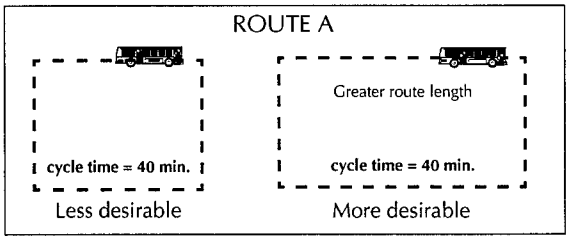
Three areas of route structure that are most influenced by service standards and policies are

a) route cycle times,
b) route configurations, and
c) interlining.

Route cycle times

Cycle time is the time it takes to drive a round trip on a route plus any time that the operator and vehicle are scheduled to take a break (layover and/or recovery time) before starting out on another trip.

Typical service standards attempt to MAXIMIZE THE LENGTH OF THE ROUTE DESIGN per cycle time, while providing for the minimum amount of layover/recovery time allowed.



Maximizing the route length per cycle time facilitates the most effective use of equipment and labor.

Maximizing route length per cycle time utilizes equipment and labor power most effectively. However, other considerations make this optimization difficult to achieve.

Other considerations that make optimization of labor and equipment difficult include...

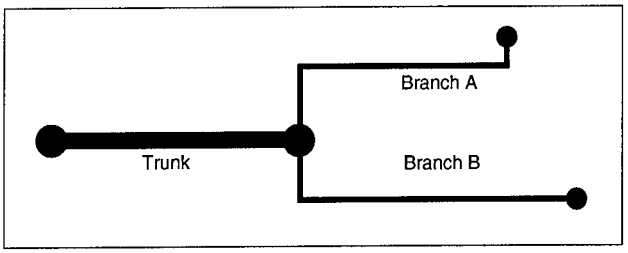
- the need to maintain consistent time between vehicles on a route (headway),
- adjusting for changes in ridership and traffic during the day (for example, rush hour vs. non rush hour), and
- planning for vehicles to arrive at common locations so that passengers may make transfers to other routes (timed transfers).

These considerations often require additional layover/recovery time beyond the mininum allowed.

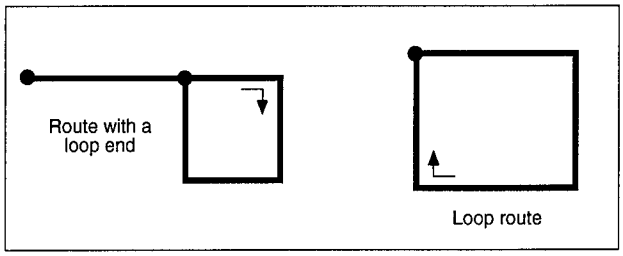
Route configurations

Route configuration is basically the definition of where the route goes. If a route is configured in a complex way, it is difficult to schedule the vehicles to be evenly spaced throughout the route (maintaining a consistent headway). However, a complex route can often lead to reduced costs because equipment and labor can be better optimized. Again, service policies and standards generally dictate a type of balance between cost efficiency and service to the public.

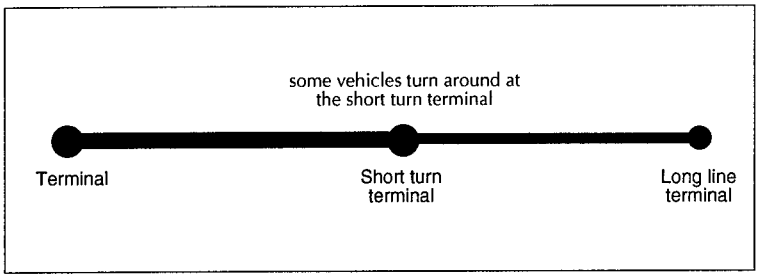
Some examples of typical route configurations



Branches



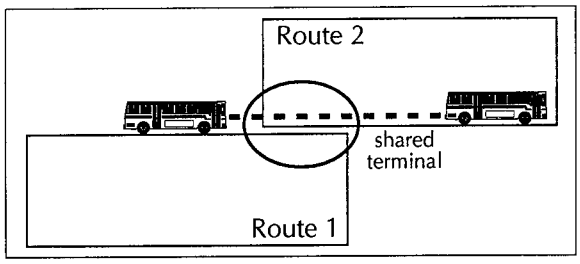
Loops



Short turn

Interlining

Interlining is the term used for scheduling a vehicle to operate from one route to another during a service day. When a vehicle is scheduled to switch over from Route 1 to Route 2, the routes are said to be interlined.



Interlining is the process of scheduling a vehicle to travel from one route to another during a service day.

Optimal interlining can result in reduced costs to the agency AND provide a convenience to the passenger. Interlining is often done for one of the following four reasons:

1- Eliminate end-of-line looping. Often a vehicle is scheduled to loop around at the end of the line. This same loop may also be done by another vehicle on another route. Combining the two loops by interlining reduces redundant time and mileage costs.

2- Lack of layover locations. Locating suitable locations for a vehicle to "park" during layover is often difficult or impossible in certain areas. Interlining can allow the vehicle to layover at a location on another route.

3 - Optimization of cycle times. The interlining of two routes with non-optimal cycle times at a common location can create overall compatible cycle times for the route pair.

4 - Reducing passenger transfers. For passengers traveling to a location that requires them to transfer from one bus to another, an interline of those routes eliminates the need to make the transfer.

Review key points by answering these questions.

1) The development of service schedules is heavily influenced by organizational service standards and policies. True or False

2) Policies and standards are generally designed to provide a logical balance between optimal cost efficiency and the provision of adequate service to the public. True or False

3) Which of the following are greatly influenced by service standards and policies?
   a) route structure
   b) service frequencies
   c) service timing
   d) management priorities

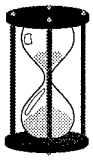
4) Where the vehicle travels on a route during the service day is related to the interconnectedness of the entire service network. True or False

5) Typical service standards attempt to maximize / minimize (choose one) the length of the route design per cycle time.

6) Three areas of route structure that are most influenced by service standards and policies are...
   a) route cycle times
   b) route configurations
   c) interlining
   d) ride checks

7) Describe any one of the four examples given for interlining.

III. Service Frequencies



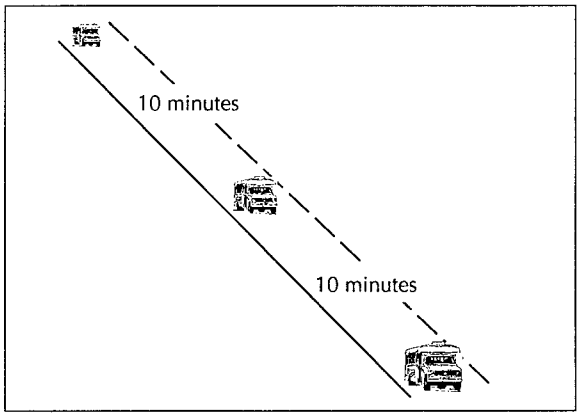
Service policies and standards also affect the development of service frequencies, i.e., how often a vehicle will come by on the route - also commonly referred to as "headway."

Three principal service policies or standards generally govern how often a vehicle is scheduled to come by on a route. They are

a) policy (or minimum) frequency,
b) demand-based frequencies, and
c) performance-based frequencies.

Policy frequencies

Some agencies simply establish by policy or standard, that on a given route, a vehicle will come by at fixed intervals — for example, every x minutes.



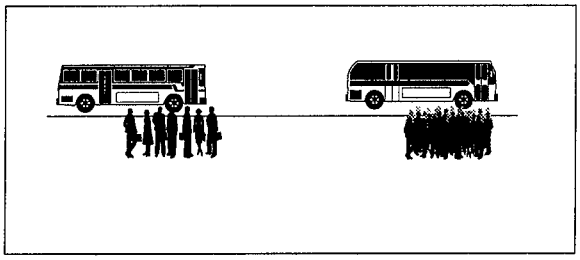
Policy frequencies often establish that a vehicle will come by on the route at fixed intervals.

A vehicle coming by every 60 minutes would be a low frequency service, while a vehicle coming by every 10 minutes would be considered a high frequency service.

Fixed interval service is a convenience to the passengers, because they know a vehicle will come by at regular intervals. However, scheduling for policy (minimum) frequencies can create cost inefficiencies by requiring excessive layover/recovery time to keep the time between vehicles constant.

Demand-based frequencies

With demand-based frequencies (or headways), the agency policy dictates that the level of service provided on the route is directly related to the number of passengers riding at one time (passenger load) and the vehicle capacity required to carry them.



Demand-based frequencies result in a level of service that is based on passenger load.

Determining passenger loading requirements is often done primarily through two methods:

Ride checks One or more data collectors rides a vehicle along the route and notes the number and locations of passenger boardings and deboardings.

Point checks One or more data collectors located at strategic points along the route records passenger boarding, deboarding and time information.

Meeting passenger load requirements of demand-based frequencies often requires adjustments in service frequency, multiple trips and/or adjusting vehicle size and capacity.

Performance-based frequencies

With this approach, service frequencies are **goal-oriented** and based on targeted performance standards. These performance standards are measured during a given service period or service day.

Performance measures typically include one or more of the following formulas.
(Note that "revenue" hours or miles means that the vehicle is in service and collecting passengers. It also includes layover time.)

Performance Measures

SERVICE EFFECTIVENESS (productivity)

Passengers per Revenue Hour	**Passengers per Revenue Mile**	**Passengers per Vehicle Trip**

COST EFFECTIVENESS

Operating Expense per Passenger	**Operating Expense per Passenger Mile**

OVERALL EFFECTIVENESS

Net Subsidy per Passenger	**Net Subsidy per Passenger Mile**	**Farebox Revenue per Cost of Service (Operating Ratio)**

IV. Service Timing

Service policies and standards influence when vehicles will come by on the system (service timing).

Four typical service timing policies are

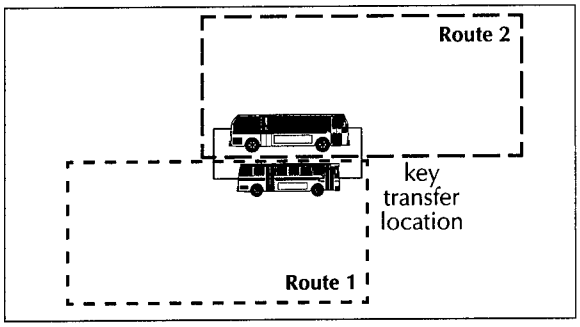
a) transfer connections,
b) trunk intertiming,
c) clock frequencies,
d) service timing hierarchy.

Transfer connections

Transit systems, depending on their size, generally need to identify key transfer connections (locations and times) that must occur in order for the entire service network to be successful.

Where service is frequent (15 minute frequencies or less), ad hoc or untimed transfers generally meet passenger needs.

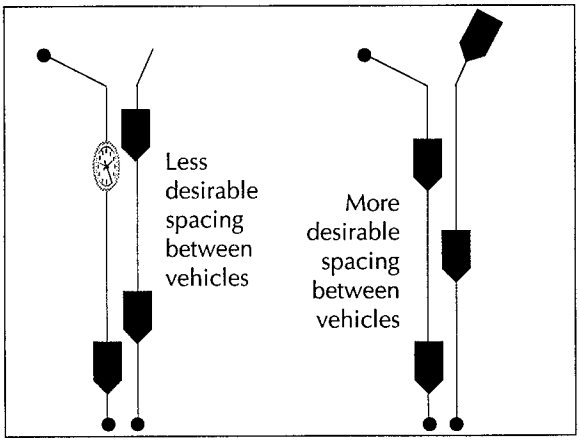
Where service is infrequent, (20 or more minutes between vehicles, timed transfers are desired when possible.



Timed and untimed transfers occur at key transfer locations.

Trunk intertiming

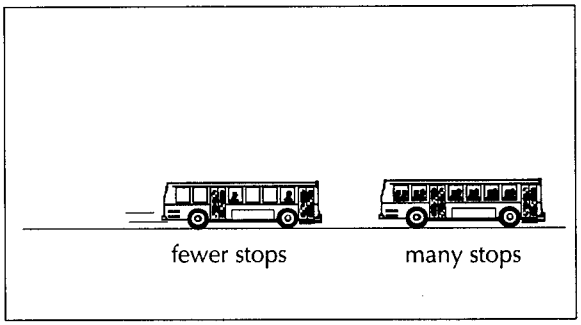
In many cases, trips on one or more routes serve a "common corridor." Coordinating the timing of these trips can result in better service to the passengers in at least two ways.



Intertiming trips that serve a common corridor results in more even frequencies and more balanced passenger loads.

First, by timing the vehicles from different routes (or multiple vehicles making trips on the same route) to be evenly spaced along the corridor, the service frequency (headway) can maintain its evenness. The passenger knows another vehicle will be along in __x__ minutes.

Secondly, the even spacing of vehicles helps to prevent "bunching." Bunching can occur when vehicles with lighter passenger loads catch up to vehicles with heavier loads. The heavier load vehicles run slower because they make more frequent stops.



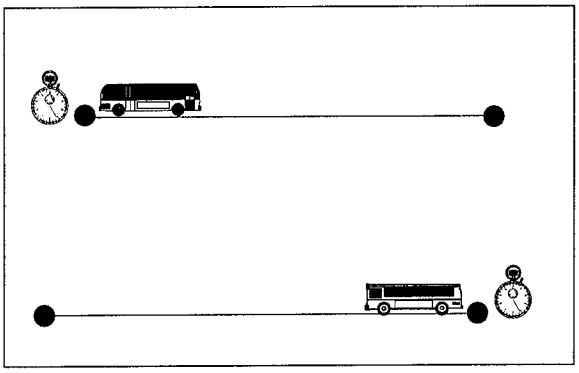
Bunching occurs when vehicles with lighter loads catch up to vehicles with heavier loads.

Clock frequencies

Clock frequencies describe trips that are scheduled to be at selected locations at regular intervals past the hour.

Scheduling vehicles to come by passenger stops at regular clock intervals is intended to be a convenience to passengers.

For example, a passenger would know that the next vehicles are scheduled to come by at 16, 26, 36, 46 minutes past the hour and so on.



With clock frequencies, one time point in each direction keys clock intervals.

Clock frequencies are usually assigned to one time point in each direction, often at the end-of-the-line.

However, it is usually difficult to operate a comprehensive clock-based system and still make necessary adjustments in running times throughout the service day.

Service timing hierarchy

The timing hierarchy identifies key time points which drive the development of individual schedules.

In the case of *timed* transfers, the hierarchy determines on which routes in the system the transfer connections are based.

As a result, there are usually two service timing hierarchies–one at the system level and one for each individual route.

Review key points by answering these questions.

1) Which one is goal-oriented: demand-based frequencies or performance-based frequencies?

2) Determining passenger loading requirements is often done primarily through which of the following methods? (choose two)

   a) ride checks
   b) call checks
   c) point checks
   d) drive checks

3) "Revenue hours" means that the vehicle is in service and collecting passengers.
   True or False

4) Transfer connections, trunk intertiming, clock frequencies and service timing hierarchy are all part of...

   a) route configuration
   b) service timing
   c) service frequency
   d) none of the above

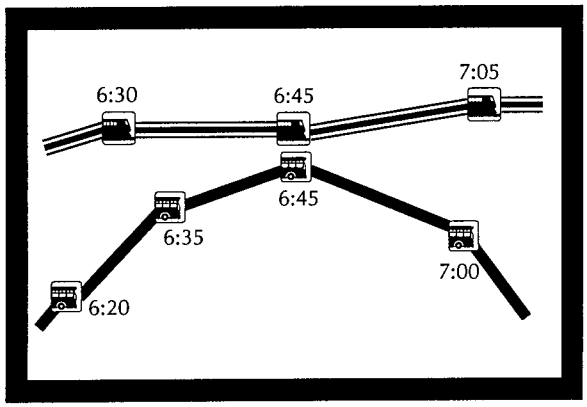
5) Where service is frequent, ad hoc or untimed transfers generally meet passenger needs.
   True or False

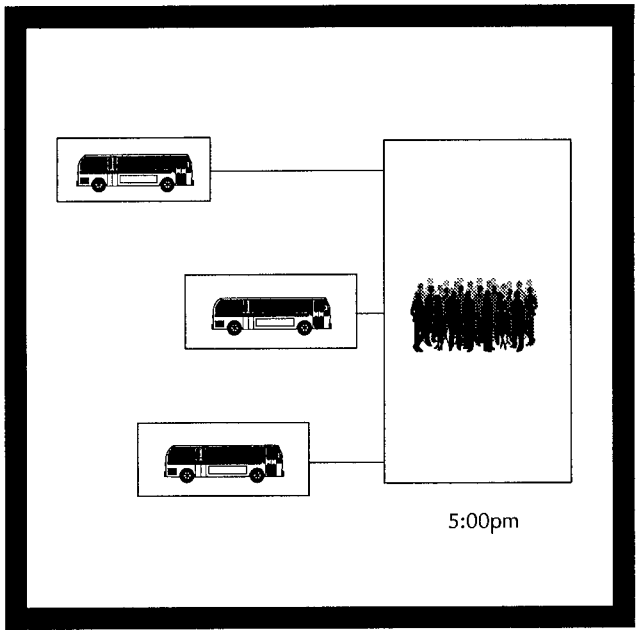
6) Describe what occurs with "bunching."

Notes:

CHAPTER 2

TRIP GENERATION





Study Objectives

1) Learn that trip generation (trip building) is the process of developing the service schedule for a route.

2) Remember what the public version of a service schedule is called.

3) Be able to recognize the definition of span of service.

4) Know the significance of the maximum load point.

5) Understand the difference between demand-based and policy-based scheduling.

6) Remember the definition of headway.

7) Learn the diagrams of branches, loops and short turns.

8) Be able to relate the number of terminal points to typical types of routes.

9) Learn the definition of cycle time.

10) Remember the difference between minimum and available cycle time.

11) Given the headway and cycle time for a route, be able to compute the number of vehicles needed to provide service on that route.

12) Learn the definition of an intermediate time point, how it is often referred to in computerized scheduling, and what location characteristics make good intermediate time points.

13) Be able to describe the difference between an internal time point and a time point found on a public timetable.

14) Learn the definition of running time.

15) Understand what operators do at relief points.

16) Remember that timed transfer considerations require revenue vehicles to converge at a common transfer location.

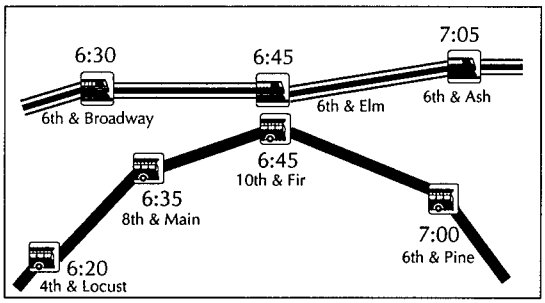
17) Given relevant information, be able to build a master schedule for a particular route.

I. Introduction

Trip generation

Trip generation (also called trip building) is the process of developing the "master" service schedule for a route.

The master service schedule, or simply, the master schedule, indicates all the times that revenue service vehicles are scheduled to be at specific locations along the route.



Trip generation is the process of determining when and where vehicles will be on a route.

The customer version of the service schedule is often called a public timetable.

Trip generation requires input from the Scheduling department as well as information from other departments, such as Planning, Operations, Marketing and Finance.

II. Policy and Planning Criteria

Span of service

The "span of service" is the duration of time (measured in hours and minutes) that vehicles are available for passenger service on a route.

The service span is measured from the beginning time of the first trip on the route to the end time of the last trip on that route.

Maximum load point

The maximum load point(s) (MLPs) is (are) the location(s) along a route where the greatest number of passengers are on board.

Having this maximum load point information, along with other factors, allows the scheduler to determine the number of vehicles that will need to pass the MLP in order to accommodate the passengers wanting to use the service.

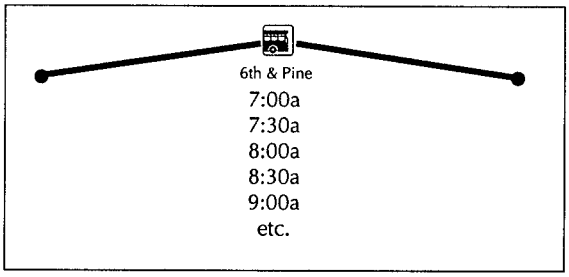
Headway

The "headway" is the time interval between two consecutive revenue vehicles operating in the same direction on a route. This is also referred to as "service frequency."

As mentioned in Chapter 1, the headway or service frequency on a route is determined either by company policy or by demand as determined by factors such as the MLP.

Policy-based frequencies

Where schedules maintain a consistent and fixed interval between vehicles on the route, the schedule is said to be "policy based."



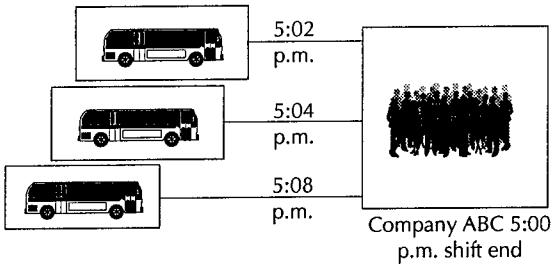
Policy-based headways operate at fixed intervals.

The fixed headway between vehicles is likely the result of low passenger demand and the desire of the company to have a minimum level of service on the route.

The headway on a policy-based schedule will often be an even "clock multiple," most commonly every 10, 15, 20, 30 minutes or on the hour, although not always.

Policy-based schedules are a convenience to the passengers, informing them that a vehicle will arrive at their passenger stop every X minutes past the hour.

Demand-based frequencies



Demand-based schedules include multiple trips spaced to accommodate the number of passengers at the maximum load points.

On routes where the volume of passengers is great at certain times and locations, more trips will need to be scheduled in order to meet the demand.

The appropriate headway for demand-based headways is generally based on

1) the number of passengers wanting the service at various locations (this includes both passengers already on board and those waiting at passenger stops).
2) the number of spaces available on the vehicle (including seats and standing room).
3) the company policy on how many people can be on board (seated and standing) at certain times and on certain vehicles, otherwise known as the "loading standard."

The loading standard is generally expressed as the percentage of passengers allowed on the vehicle to the actual seating capacity of the vehicle.

For example, if the loading standard is established by company policy as 133% on a vehicle with 45 seats, then 60 persons is the target (but not a cutoff) for maximum capacity.

Example:

$$\underset{\text{loading standard}}{133\%} = \frac{60 \text{ spaces}}{45 \text{ seats}}$$

The loading standard is the percentage of passengers the company will target as a maximum load. It is expressed as a percentage of the number of seats available.

Example: Demand-based frequencies

In this example, 3 trips serve the passenger stop in front of ABC Corporation around 5:00 p.m. as follows:

Current Service

Trip	On Board	Boarding	Total
5:02	34	48	82
5:04	46	35	81
5:08	41	24	65
TOTAL	121	107	228

Loading standard (%) = 125%
Vehicle seating capacity = 45

target maximum # of passengers for each vehicle...

125% * 45 = 57

Since 3 vehicles with a loading standard of 57 each equals 171 (3 x 57), then 57 passengers (228 - 171) are not being provided rides or are boarding and overcrowding the vehicles.

Solution

Adding another trip by a similar sized vehicle during the period will provide enough vehicle space.

$$\underset{\text{(spaces needed)}}{228 \text{ riders}} \;/\; \underset{\text{loading standard}}{57 \text{ spaces per}} = 4 \text{ vehicles}$$

Trips to that location around 5:00 p.m. are revised to the following schedule:

Trips

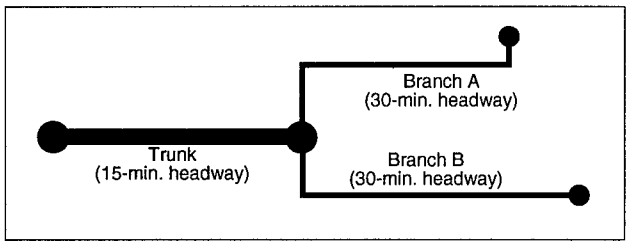
5:00
5:03
5:07
5:12

Route patterns

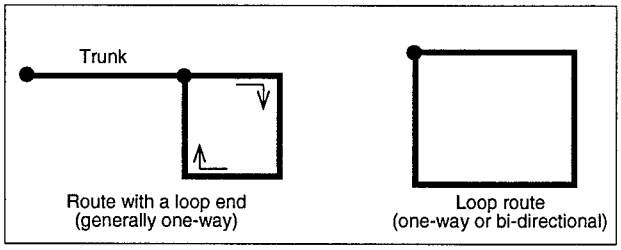
Routes often consist of a trunk or main path providing the same frequency of service over the entire length of the route. Route variations include trips whose path deviates from the trunk in some manner. These basic route deviations are referred to as branches, loops, and short turns.

Examples of branches, loops and short turns

The following diagrams illustrate three typical deviations from the main trunk of a route.

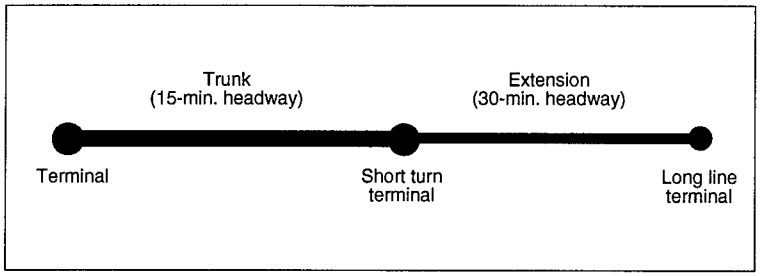


Branches



Loops

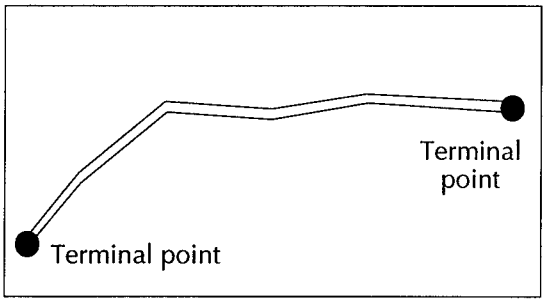
● denotes Terminal Location



Short turn

Terminal points

Terminal points are considered the "ends" of a line or route. These are the locations where vehicles generally begin and/or end their trips and operators usually take their layovers.



Terminal points are considered ends of the line.

For that reason, locations where there is safe parking and restrooms close by are considered desirable locations for terminal points.

How many terminal points are usually on a route?

Loop routes that operate only in one direction generally have only one terminal point.

A basic end-to-end route with bi-directional service and no branches or short turns generally has two terminal points, one located at each end of the route.

Routes with more complex patterns generally have more than two terminal points.

Review key points by answering these questions.

1) The master service schedule indicates all the times that revenue service vehicles are scheduled to be at specific locations along the route.

   True or False

2) The customer version of the service schedule is often called a _____ _____ .

3) What is the span of service?

4) The maximum load point (MLP) represents a point along the route where the *greatest / fewest* (choose one) number of passengers are on board.

5) The headway is the time interval between two consecutive revenue vehicles operating in the same direction on a route. True or False

6) Headway is sometimes referred to as _____ _____ .

7) A fixed headway between vehicles is likely the result of low passenger demand and the desire of the company to have a minimum level of service on the route.

   The above sentence refers to *policy-based* or *demand-based* headways. (choose one)

8) On routes where the volume of passengers is great at certain times and locations, more trips will need to be scheduled in order to meet the demand.

   The above sentence refers to *policy-based* or *demand-based* headways. (choose one)

9) Define loading standard.

10) If a vehicle had 40 seats and a loading standard of 150%, what is the target maximum load?

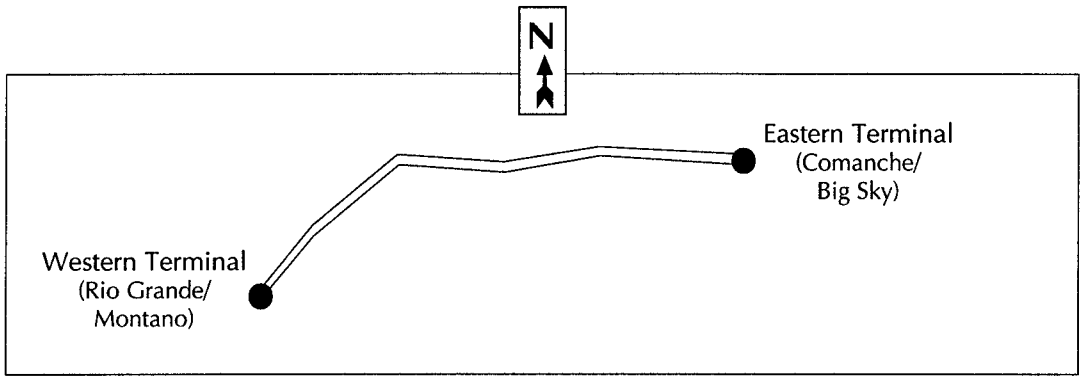
11) Branches, loops and short turns are examples of route pattern variations. True or False

12) Operators generally take their layovers at terminal points. True or False

13) Match the following:

end-to-end route	one terminal
complex route	two terminals
loop route	more than two terminals

IN THE FOLLOWING SECTIONS, ROUTE 32 WILL BE DEVELOPED TO ILLUSTRATE THE TRIP BUILDING PROCESS AND TO DEMONSTRATE NEW CONCEPTS.



Route 32

Route 32 will have two terminals or end points. The western terminal is located at Rio Grande & Montano. The eastern terminal is located at Comanche & Big Sky.

The time it takes for one vehicle to operate passenger service from one terminal to the other (excluding layover/ recovery time) is 36 minutes (72 minutes round trip).

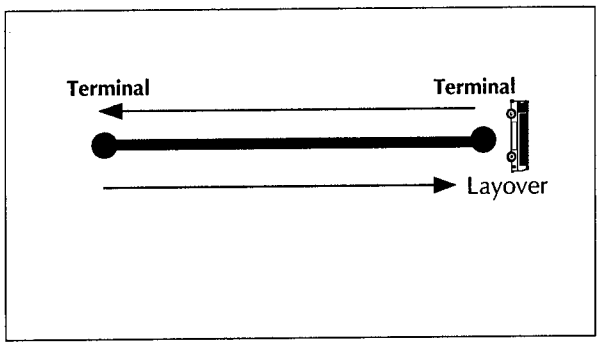
By agency agreement, the minimum layover/recovery time per round trip is established at 10% of the round trip running time.

Trips generated for this route will operate bi-directionally between the two terminals, operating on a policy-based 30-minute headway.

The service span will be during peak hours only. In this case, approximately 6:00 a.m. - 10:30 a.m. and 1:30 p.m. - 6:30 p.m.

Cycle time

Cycle time is the number of minutes needed to make a round trip on the route, including layover/recovery time.



Cycle time is the time needed to make a round trip, including layover/recovery time.

Cycle time is important for several reasons, including playing a part in the formula used for determining the number of vehicles needed to provide a given level of service on a route. (See next page.)

Since cycle time equals the number of minutes needed to make a round trip, including the layover/recovery time, the scheduler determines the amount of time it takes to operate or "run" from one end of the route to the other and back, then adds layover/recovery time to yield the cycle time.

Minimum vs. Available Cycle Time

For many agencies, on some or all routes, the amount of layover/recovery time is often determined by labor agreement or agency policy.

These agreements or policies dictate a minimum number of minutes that must be built into the schedule for layover/recovery.

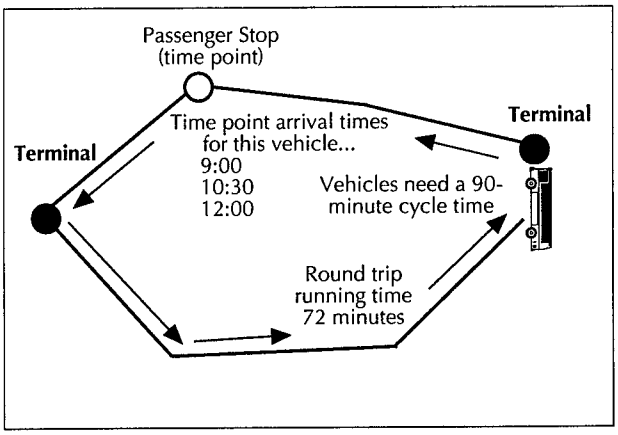
Minimum cycle time is the number of minutes scheduled for the vehicle to make a round trip, including a minimum layover/recovery time as dictated by labor agreement or agency policy. In the example of Route 32, the minimum layover/recovery time is 10% of the round trip time.

However, maintaining a constant headway, such as the policy-based, 30-minute headway for Route 32, will, in most cases, result in a cycle time OTHER THAN THE MINIMUM CYCLE TIME for the vehicles operating that route.

In the case of Route 32, it will be necessary for vehicles to layover/recover longer than the minimum 10% agency requirement. Otherwise, they would leave the layover point too soon and arrive at the stops along the route sooner than the schedule indicates.

Therefore, additional (sometimes called "excessive") layover/recovery time is necessary to maintain the 30-minute headway on Route 32.

The resulting cycle time (which includes the additional layover/recovery time) necessary to maintain the 30-minute headways is now called the *available cycle time.*



Available cycle time includes excessive layover/recovery time necessary to maintain constant headways.

In the optimal case, the minimum cycle time would be the same as the available cycle time. However, maintaining fixed, clock multiple headways often makes that impossible.

So how many vehicles would be needed to maintain the 30-minute headway on Route 32?

To operate the 30-minute headway on Route 32 (or any consistent headway on any route), a simple formula is used to determine the number of vehicles needed.

$$\frac{\text{Cycle time}}{\text{Desired Headway}} = \textbf{\# Vehicles}$$

Formula for computing the number of vehicles needed to operate a given headway.

Given the minimum layover/recovery time for Route 32 of 10% of round trip time, the number of vehicles needed is initially computed as follows:

Minimum cycle time:

= (round trip time + min. layover/recovery)
= (72 + (10% x 72))
= (72 + 7.2)
(7.2 is rounded to the next whole number 8)
= **(72 + 8)**
= **80**

Desired Headway:
= (30) minutes

$$\frac{80}{30} = \textbf{2.67}$$

Obviously, it is not possible to operate 2.67 vehicles. The number of vehicles needed would be rounded up to three (3).

Substituting 3 for 2.67 means the cycle time would have to change if the 30-minute headway remains constant.

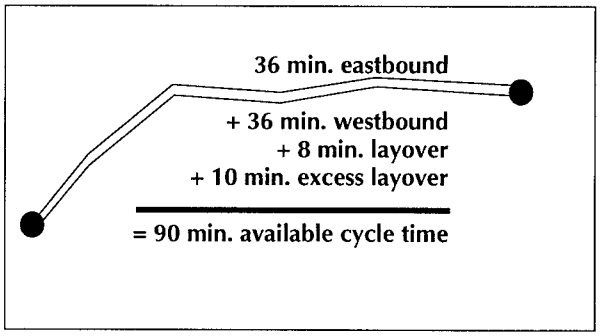
$$\frac{\text{? (cycle time)}}{\text{30 (minute headway)}} = \textbf{3 vehicles}$$

Solving the equation for available cycle time...

$$\frac{90}{30} = 3$$

Maintaining the 30-minute headway yields an available cycle time of 90 minutes.

With a round trip running time of 72 minutes, this means that **18 minutes** of layover/recovery time per round trip is necessary to maintain the 30-minute headway, while utilizing 3 vehicles.



Ninety minutes of available cycle time for Route 32 includes 18 minutes of layover/ recovery per round trip.

In general, can schedulers do anything else with excess layover/recovery time?

Excess layover/recovery time generally is used by the scheduler in one of 5 different ways:

1) to maintain consistent headways (as with Route 32).

2) to allow route deviations (changes in where the vehicle goes on the route).

3) to modify the headway (i.e., longer or shorter headways for more efficient vehicle utilization).

4) to lengthen the route where there is enough available cycle time.

5) to facilitate interlining with other routes.

Recap of cycle time, # of vehicles, headway, and span of service for Route 32

Westbound running time	=	36 minutes	Westbound running time	=	36 minutes
Eastbound running time	=	36 minutes	Eastbound running time	=	36 minutes
TOTAL RUNNING TIME	=	72 MINUTES	TOTAL RUNNING TIME	=	72 MINUTES
Contract layover (10%)	=	8 minutes	Layover for 30-min. headway	=	18 minutes
MINIMUM CYCLE TIME	=	**80 MINUTES**	**AVAILABLE CYCLE TIME**	=	**90 MINUTES**

 # Vehicles = $\frac{90}{30}$ = 3

Headway = 30 minutes

Span of service:

Peak service hours 6:00 a.m. - 10:30 a.m.

and 1:30 p.m. - 6:30 p.m. weekdays

III. Other Data

Intermediate time points

Intermediate time points are locations along the route, between the terminals, that indicate when the vehicle will be there. The term "node" is commonly used in computerized scheduling systems to denote a time point.

Generally speaking, on public timetables, these intermediate time points, or nodes, are timed to be between 6 and 10 minutes apart.

In theory, when intermediate time points are too close together, there is a greater risk that the operator may arrive early and have to wait or "dwell" at that point to stay on schedule, causing passengers to become impatient.

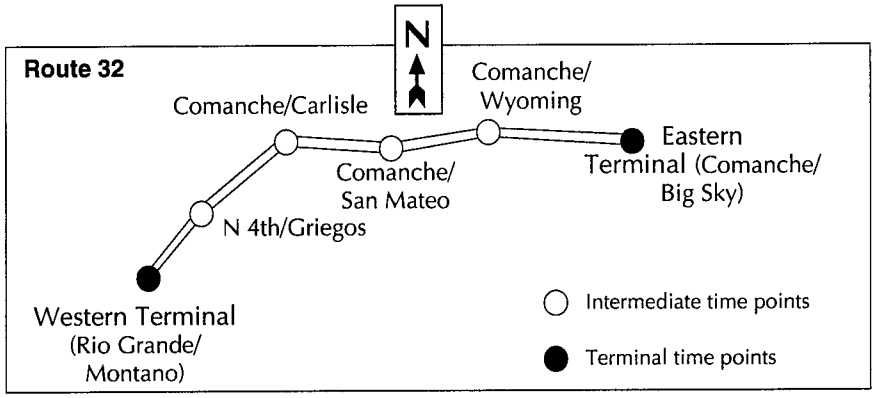
When time points are more than 10 minutes apart, some agencies believe that customers are more likely to be confused about when a vehicle will arrive at a particular stop, given the differences in individual operator driving habits.

Where are intermediate time points typically located?

Physical location considerations also affect the selection of intermediate time points. Major intersections that are widely recognized and possess good pedestrian amenities like sidewalks and actuated traffic signals make good time points.

It is a good idea to locate intermediate time points at major trip generator locations such as shopping centers, hospitals, and government buildings. Time points are also useful at locations where time is critical, such as major employment centers and intersecting bus routes or rail centers.

Route 32 has four (4) intermediate time points.



Internal time points

Internal time points provide more detailed location and time information. They may appear on the schedule used by the operator (sometimes called a run paddle) but not on the public timetables.

These internal time points, typically spaced three (3) to five (5) minutes apart, are meant to serve as a reference for both operators and supervisors to determine if a particular trip is running early (hot) or late.

Running time

Running time refers to the number of scheduled minutes assigned to a revenue vehicle for moving from one time point location to the next.

Running times are accurate when they are sensitive to the varying traffic conditions and passenger volumes over the course of a service day.

Too little running time can cause operators to become frustrated and rushed trying to stay on time, creating potential safety problems such as speeding, pushing traffic lights and being abrupt with passengers.

Too much running time creates unnecessary travel time for passengers and the inefficient utilization of equipment and operators. It may also contribute to operators running early (hot), which may result in some passengers missing their trips.

Inaccurate running times also contribute to missed transfers, schedule reliability complaints and time-consuming (and expensive) schedule corrections.

Running time files

Because running times between time points often vary by time of day or day of the week, they are often stored in a running time file. In a typical example of a running time file, the names of time points are listed down the left-hand column while timing periods are listed across the top.

ROUTE 32 (Example running time file)

Service Day: Weekday

Direction: Westbound

Time Point	Early A.M.	A.M. Peak	Base	School	P.M. Peak	Evening	Night
Comanche @ Big Sky	-	-	-	-	-	-	-
Comanche @ Wyoming	9	9	-	-	9	9	-
Comanche @ San Mateo	6	6	-	-	6	6	-
Comanche @ Carlisle	4	4	-	-	4	4	-
N. 4th @ Griegos	10	10	-	-	10	10	-
Rio Grande @ Montano	7	7	-	-	7	7	-
TOTAL	36	36	-	-	36	36	-

Example running time file for Route 32

Review key points by answering these questions.

1) Cycle time is the number of minutes needed to make a round trip on a route, including layover/ recovery time. True or False

2) Minimum cycle time includes a minimum layover/recovery time generally determined by labor agreement or agency policy. True or False

3) Maintaining consistent headways may result in a cycle time other than the minimum cycle time. True or False

4) Cycle time that includes excessive layover/recovery time is called _ _ _ _ _ _ _ _ _ cycle time.

5) Write the formula used for computing the number of vehicles needed to operate a route.

6) Which of the following was not listed as a consideration for the scheduler when dealing with excessive cycle time?

   a) to maintain consistent headways

   b) to shorten the route

   c) to allow route deviations

   d) to facilitate interlining with other routes

7) A "node" is a time point. True or False

8) Major intersections that are widely recognized and possess good pedestrian amenities like sidewalks and actuated traffic signals make good time points. True or False

9) Internal time points are often found on public timetables. True or False

10) Running time refers to the number of scheduled minutes assigned to a revenue vehicle to move from one time point location to _____ .

11) Match the following:

Too much running time	abruptness with passengers
Too little running time	unnecessary passenger travel time

12) What does a running time file do?

Controlling time points

Most schedules are constructed around one or more controlling time points. Controlling time points are specific arrival and/or departure locations that affect one or more trips along the route.

Specific arrival and/or departure times may result from the need to be at a certain location at a certain time, generally because a major passenger load can be expected. Examples include schools, major employment centers and coordinated (timed) transfers between two revenue service vehicles.

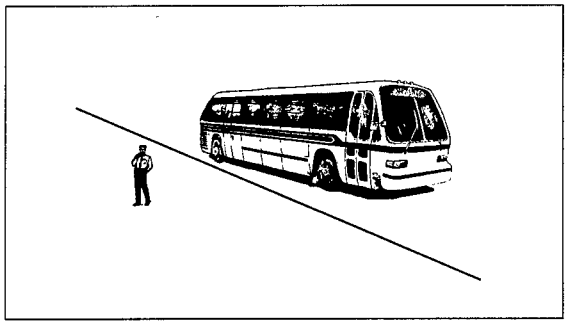
Controlling time points often include the maximum load point on a route.

Relief points

Relief points are points along the route where an operator (but not necessarily a vehicle) begins (and another operator ends) a work shift or part of a work shift.

Although operators may typically begin their service day at the garage facility and drive the revenue vehicle to a starting point along the route (usually a terminal), many operators relieve other operators at a point along the route at a given time and proceed along the route with that vehicle.

This typically occurs when the total number of hours that a revenue service vehicle operates in a given workday exceeds the time that a single operator can work.

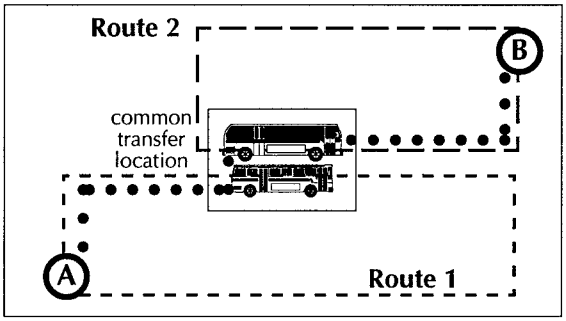


Relief points are locations where one operator relieves another operator and continues in revenue service with that vehicle.

Timed transfer considerations

Coordinating passenger transfers between revenue vehicles operating on different routes may require those vehicles to converge at a common transfer location at the same time.

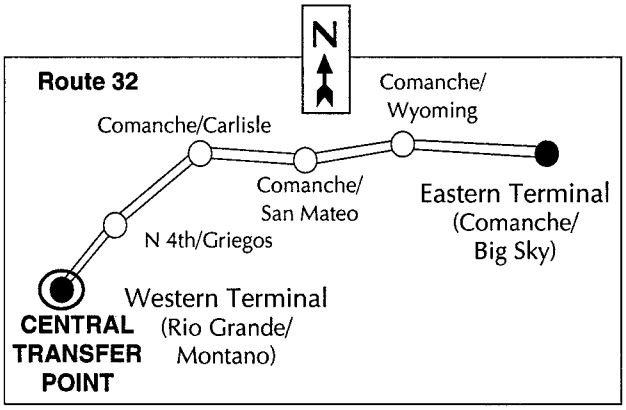
Passengers can then leave the first vehicle and transfer to the next vehicle for a continuing trip on another route (as in point A to B below).



Timed transfers require that vehicles converge upon a common location so that passengers can depart one vehicle to board another.

For Route 32, the western terminal is considered the central transfer point for the system.

Therefore, arrival times need to be timed in order to accommodate passenger transfers from Route 32 to other routes.



For Route 32, the western terminal is the central transfer point where passengers can transfer to other routes.

IV. Master Schedule Development

The next step in the process is to build individual trips into a master schedule for the route. The master schedule depicts all trips made on that route. Different master schedules typically cover weekdays, Saturdays and/or Sundays and/or holidays for a given route.

Format

Master schedules are built utilizing a format that lists the trips either vertically or horizontally. Vertical listing of trips will be used for Route 32.

Abbreviations

Time points are often abbreviated into standard three or four digit codes. Most computerized scheduling systems require abbreviations. Route 32 time points will be abbreviated as follows:

CBS	Comanche @ Big Sky
COW	Comanche @ Wyoming
CSM	Comanche @ San Mateo
COC	Comanche @ Carlisle
4GR	N. 4th @ Griegos
RGM	Rio Grande @ Montano

Building a base headway

As previously noted, Route 32 is intended to operate a 30-minute headway during peak hours only (approximately 6:00 a.m. - 10:30 a.m. and 1:30 p.m. - 6:30 p.m.). No off-peak or evening trips are needed. Three vehicles will be used.

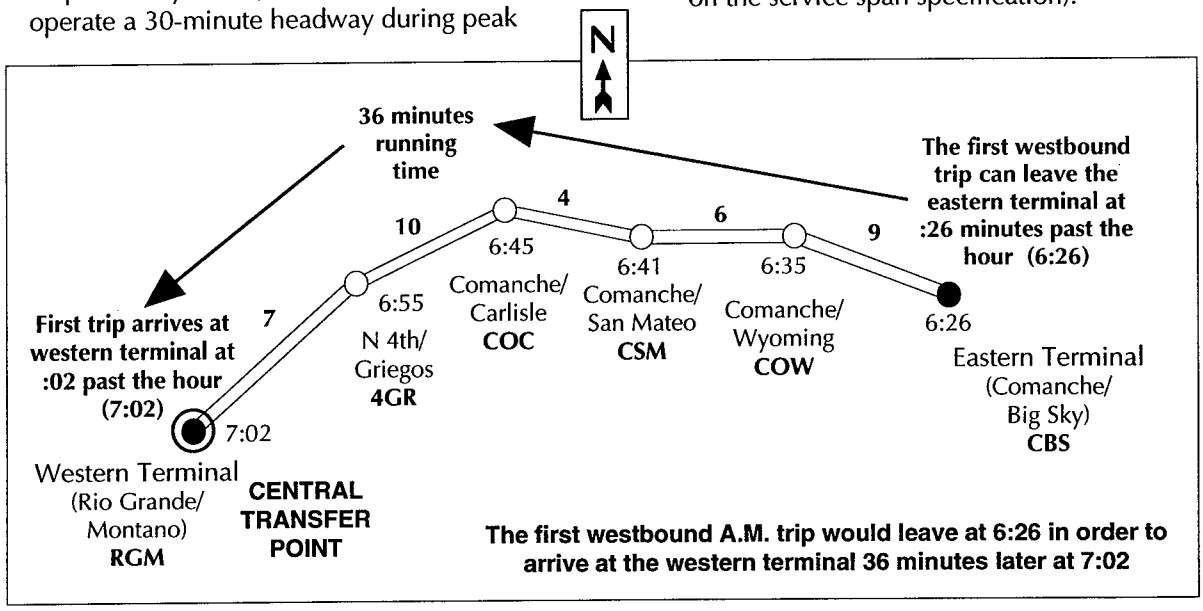
Which trips will be built first, westbound or eastbound?

A number of factors can influence the initiation of trip building by direction. In the case of Route 32, the western terminal is considered the central transfer point for the system. Since Route 32 trips need to converge on the western (outer) terminal at specific times to facilitate timed transfers, westbound trips will be generated first.

How are departure times for the trips determined?

Typically, selected routes converge on a transfer center at about the same time. Since other routes in the system converge on the western terminal (the central transfer location) at :02 and :32 past the hour, trips on Route 32 should also converge there at :02 and :32 past the hour.

Since the running time for westbound trips has been established at 36 minutes, the first trip leaving the eastern terminal must leave at 6:26 a.m. to arrive 36 minutes later at 7:02 a.m. (Remember, no service before 6:00am based on the service span specification).



Since Route 32 is operating a 30-minute headway, the next westbound trip (2W) has to depart the eastern terminal (**CBS**) at _____ (fill in the time).

The remaining westbound trips, as seen below, are now generated as the master schedule for Route 32 continues to build with westbound A.M. trips. The times for each time point are derived from the running times file presented earlier, and the intent to maintain a 30-minute headway.

Route 32 - Westbound
Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32

The P.M. westbound weekday trips are built next. Again, the P.M. service plan is to operate from approximately 1:30 p.m. until 6:30 p.m. The first P.M. trip, 9W, must leave the eastern terminal at 1:26 to arrive at the western terminal at 2:02. The last trip, 18W, is scheduled to arrive at RGM at 6:32.

Continue building the master schedule by completing the times for the remaining P.M. westbound trips. (Answers are on the next page.)

9W	**1:26**	**1:35**	**1:41**	**1:45**	**1:55**	**2:02**
10W						
11W						
12W						
13W						
14W						
15W						
16W						
17W						
18W						**6:32**

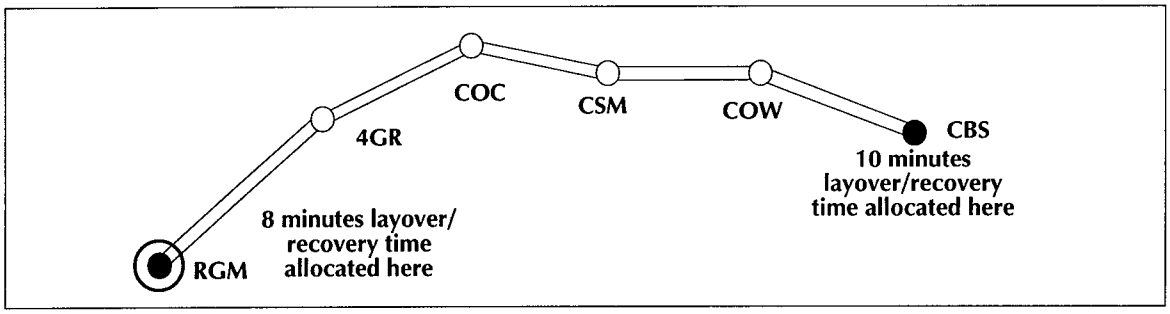
Route 32 - Westbound
Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32
9W	**1:26**	**1:35**	**1:41**	**1:45**	**1:55**	**2:02**
10W	**1:56**	**2:05**	**2:11**	**2:15**	**2:25**	**2:32**
11W	**2:26**	**2:35**	**2:41**	**2:45**	**2:55**	**3:02**
12W	**2:56**	**3:05**	**3:11**	**3:15**	**3:25**	**3:32**
13W	**3:26**	**3:35**	**3:41**	**3:45**	**3:55**	**4:02**
14W	**3:56**	**4:05**	**4:11**	**4:15**	**4:25**	**4:32**
15W	**4:26**	**4:35**	**4:41**	**4:45**	**4:55**	**5:02**
16W	**4:56**	**5:05**	**5:11**	**5:15**	**5:25**	**5:32**
17W	**5:26**	**5:35**	**5:41**	**5:45**	**5:55**	**6:02**
18W	**5:56**	**6:05**	**6:11**	**6:15**	**6:25**	**6:32**

Now that westbound trips are scheduled, how are the eastbound trips added?

Building the eastbound weekday trips on Route 32 follows much the same process, except that layover/recovery time has yet to be allocated. In this case, the **18** minutes of layover/recovery must be built into the schedule per round trip.

It has been arbitrarily determined by the agency that 8 minutes will be taken at the western terminal (**RGM**) and 10 minutes will be taken at the eastern terminal (**CBS**).



8 minutes of layover/recovery time is to be taken at the western terminal (RGM) and 10 minutes at the eastern terminal (CBS).

Eastbound weekday trips for Route 32

When does the first eastbound trip start?

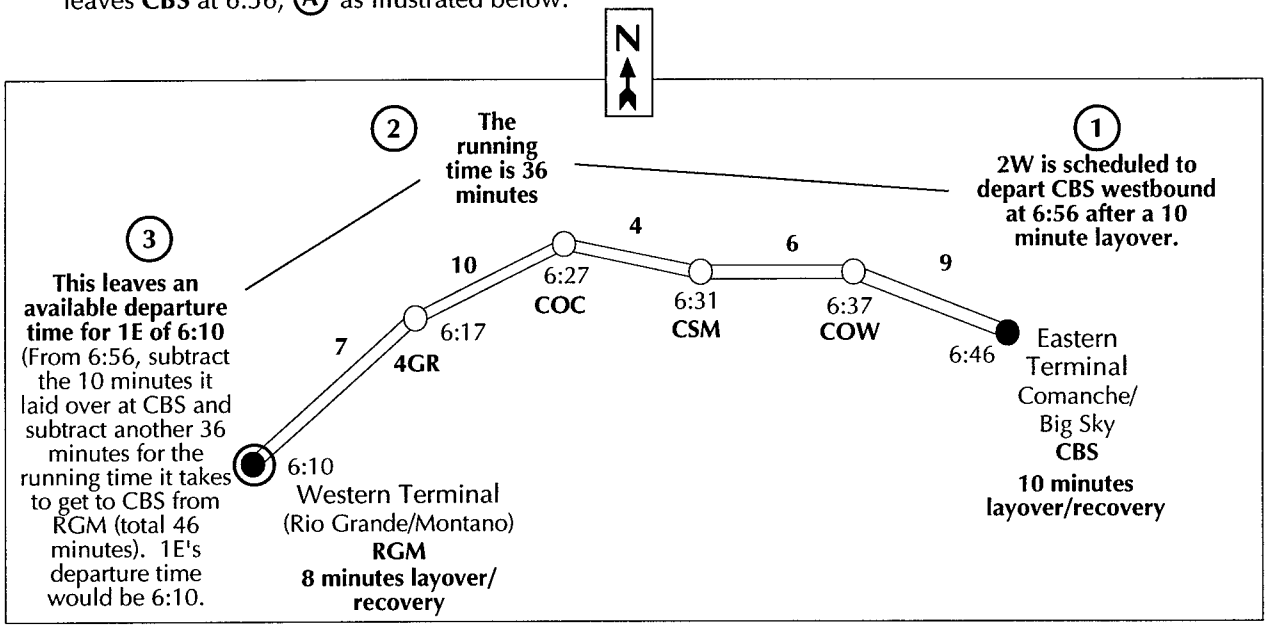
Schedulers often think in terms of "tying" or "hooking" trips together. In this case, they might see if the vehicle already scheduled to make the first westbound trip (1W at 6:26) could make an eastbound trip first.

The first eastbound trip (1E) preceding 1W would have to leave eastbound well before the planned 6:00 a.m. span of service. However, (1E) could start eastbound at 6:10 a.m. and make the second westbound trip (2W), which leaves **CBS** at 6:56, Ⓐ as illustrated below.

Route 32 - Westbound Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
1W	6:26	6:35	6:41	6:45	6:55	7:02
Ⓐ 2W	6:56	7:05	7:11	7:15	7:25	7:32
3W	7:26	7:35	7:41	7:45	7:55	8:02
4W	7:56	8:05	8:11	8:15	8:25	8:32
5W	8:26	8:35	8:41	8:45	8:55	9:02
6W	8:56	9:05	9:11	9:15	9:25	9:32
7W	9:26	9:35	9:41	9:45	9:55	10:02
8W	9:56	10:05	10:11	10:15	10:25	10:32

The scheduler determines that 6:10 must be the starting time for 1E by subtracting out the 10 minutes the vehicle is at CBS for layover and by subtracting out the 36 minute running time it will take to get to CBS from RGM.



The eastbound trip schedule then proceeds in much the same way, maintaining a 30-minute headway and providing 10-minute layovers at **CBS** and 8-minute layovers at **RGM**.

Complete the partial schedule below for intermediate time points for eastbound trips 2E and 3E. Hint: remember the 30-minute headways. (Answers can be found on the following page.)

Route 32 -Eastbound Weekday

Note how the order of time points changes with direction of travel (now eastbound)

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40					7:16
3E	7:10					7:46

Route 32 - Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16

No A.M. trip 9E is scheduled because it would arrive at CBS at 10:56 – 26 minutes past the 10:30 span of service plan.

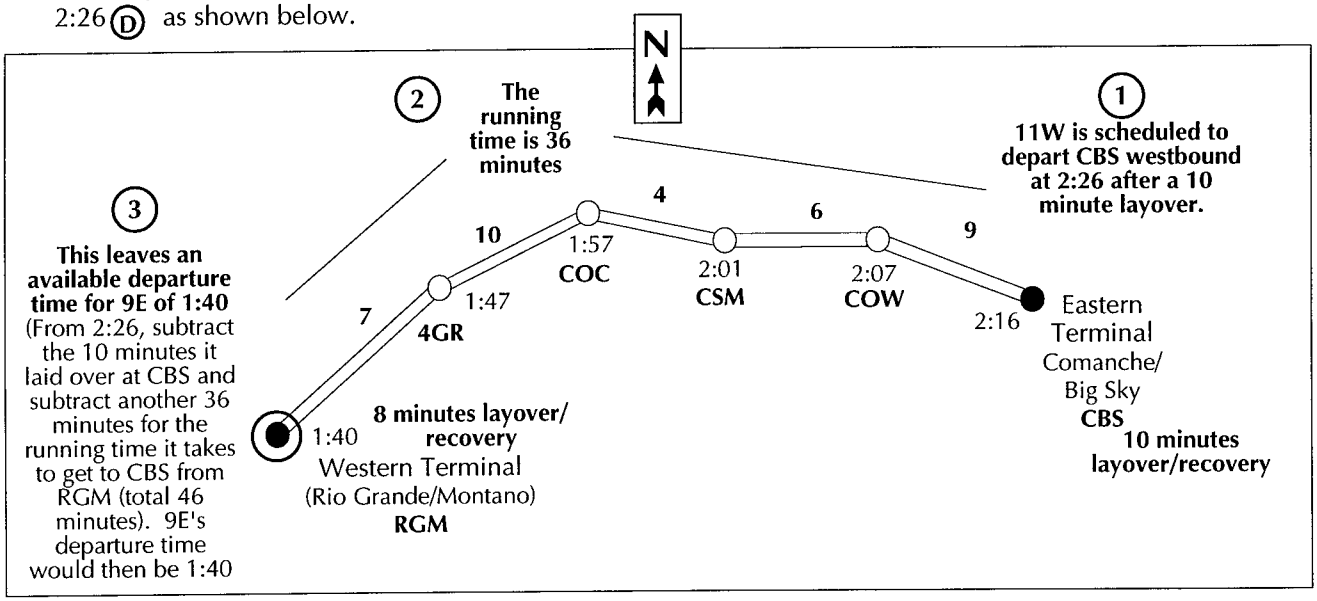
When does the first P.M. eastbound trip start?

The agency planned for P.M. service to start around 1:30 p.m. for Route 32 and run until approximately 6:30 p.m. The P.M. westbound schedule (shown reduced at right) shows the first P.M. westbound trip (9W) departing at 1:26 (B) and 10W departing at 1:56. (C)

Subtracting 46 minutes (10 minutes layover and 36 minutes running time) from either time results in an eastbound trip leaving earlier than the 1:30 service plan. Therefore, the first "hook" would come with a P.M. eastbound vehicle preceding 11W which leaves CBS at 2:26 (D) as shown below.

Route 32 - Westbound
Weekday

Trip No.	CBS	COW	CSM	COC	4GR	RGM
9W	1:26 (B)	1:35	1:41	1:45	1:55	2:02
10W	(C) 1:56	2:05	2:11	2:15	2:25	2:32
11W	2:26 (D)	2:35	2:41	2:45	2:55	3:02
12W	2:56	3:05	3:11	3:15	3:25	3:32
13W	3:26	3:35	3:41	3:45	3:55	4:02
14W	3:56	4:05	4:11	4:15	4:25	4:32
15W	4:26	4:35	4:41	4:45	4:55	5:02
16W	4:56	5:05	5:11	5:15	5:25	5:32
17W	5:26	5:35	5:41	5:45	5:55	6:02
18W	5:56	6:05	6:11	6:15	6:25	6:32



The P.M. eastbound trip schedule then proceeds in much the same way, maintaining a 30-minute headway, until the last P.M. trip arrives at **CBS** at 5:46.

Complete the partial schedule below for intermediate time points for eastbound trips 10E through 18E. (Answers can be found on the following page.)

Route 32 -Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16
9E	**1:40**	**1:47**	**1:57**	**2:01**	**2:07**	**2:16**
10E	**2:10**					**2:46**
11E	**2:40**					**3:16**
12E	**3:10**					**3:46**
13E	**3:40**					**4:16**
14E	**4:10**					**4:46**
15E	**4:40**					**5:16**
16E	**5:10**					**5:46**

Route 32 -Eastbound
Weekday

Trip No.	RGM	4GR	COC	CSM	COW	CBS
1E	6:10	6:17	6:27	6:31	6:37	6:46
2E	6:40	6:47	6:57	7:01	7:07	7:16
3E	7:10	7:17	7:27	7:31	7:37	7:46
4E	7:40	7:47	7:57	8:01	8:07	8:16
5E	8:10	8:17	8:27	8:31	8:37	8:46
6E	8:40	8:47	8:57	9:01	9:07	9:16
7E	9:10	9:17	9:27	9:31	9:37	9:46
8E	9:40	9:47	9:57	10:01	10:07	10:16
9E	**1:40**	**1:47**	**1:57**	**2:01**	**2:07**	**2:16**
10E	**2:10**	**2:17**	**2:27**	**2:31**	**2:37**	**2:46**
11E	**2:40**	**2:47**	**2:57**	**3:01**	**3:07**	**3:16**
12E	**3:10**	**3:17**	**3:27**	**3:31**	**3:37**	**3:46**
13E	**3:40**	**3:47**	**3:57**	**4:01**	**4:07**	**4:16**
14E	**4:10**	**4:17**	**4:27**	**4:31**	**4:37**	**4:46**
15E	**4:40**	**4:47**	**4:57**	**5:01**	**5:07**	**5:16**
16E	**5:10**	**5:17**	**5:27**	**5:31**	**5:37**	**5:46**

How are trips in all directions combined onto one master schedule?

The typical convention for combining trips in both directions onto a master schedule begins with displaying time point locations horizontally along the top of the schedule (in each direction) with columns underneath. Trip numbers and times are also displayed horizontally.

For Route 32 shown on the next page, westbound trips are shown on the left-hand side and eastbound trips are show on the right-hand side of the black vertical divider.

Now that all the trips are shown on the master schedule, how are vehicles assigned to make the trip?

Blocking is the process of assigning trips to vehicles (see Chapter 3).

During an effective blocking process, trips are hooked together and assigned to a vehicle in the most logical and efficient manner possible.

Completed master schedule for Route 32

Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
6:26	6:35	6:41	6:45	6:55	7:02							
6:56	7:05	7:11	7:15	7:25	7:32		6:10	6:17	6:27	6:31	6:37	6:46
7:26	7:35	7:41	7:45	7:55	8:02	A	6:40	6:47	6:57	7:01	7:07	7:16
7:56	8:05	8:11	8:15	8:25	8:32	M	7:10	7:17	7:27	7:31	7:37	7:46
8:26	8:35	8:41	8:45	8:55	9:02		7:40	7:47	7:57	8:01	8:07	8:16
8:56	9:05	9:11	9:15	9:25	9:32		8:10	8:17	8:27	8:31	8:37	8:46
9:26	9:35	9:41	9:45	9:55	10:02		8:40	8:47	8:57	9:01	9:07	9:16
9:56	10:05	10:11	10:15	10:25	10:32		9:10	9:17	9:27	9:31	9:37	9:46
							9:40	9:47	9:57	10:01	10:07	10:16
1:26	1:35	1:41	1:45	1:55	2:02							
1:56	2:05	2:11	2:15	2:25	2:32		1:40	1:47	1:57	2:01	2:07	2:16
2:26	2:35	2:41	2:45	2:55	3:02		2:10	2:17	2:27	2:31	2:37	2:46
2:56	3:05	3:11	3:15	3:25	3:32		2:40	2:47	2:57	3:01	3:07	3:16
3:26	3:35	3:41	3:45	3:55	4:02		3:10	3:17	3:27	3:31	3:37	3:46
3:56	4:05	4:11	4:15	4:25	4:32	P	3:40	3:47	3:57	4:01	4:07	4:16
4:26	4:35	4:41	4:45	4:55	5:02	M	4:10	4:17	4:27	4:31	4:37	4:46
4:56	5:05	5:11	5:15	5:25	5:32		4:40	4:47	4:57	5:01	5:07	5:16
4:26	4:35	4:41	4:45	4:55	5:02		5:10	5:17	5:27	5:31	5:37	5:46
5:56	6:05	6:11	6:15	6:25	6:32							

Review key points by answering these questions.

1) Specific arrival and/or departure locations that affect one or more trips along the route are called...

   a) Intermediate time points
   b) Controlling time points
   c) Nodes
   d) Relief points

2) Timed transfers require that vehicles converge upon a common location so that passengers can depart one vehicle to board another vehicle making trips on a different route. True or False

3) The same master schedule generally covers weekday, Saturday, Sunday and holiday service. True or False

4) Times for each time point are derived from the _____ ____ file.

5) Schedulers often think in terms of tying or hooking trips together. True or False

6) _____ is the process of assigning trips to vehicles.

7) In the example below, complete trips 1W, 2W and 3W using the running times file at right below.

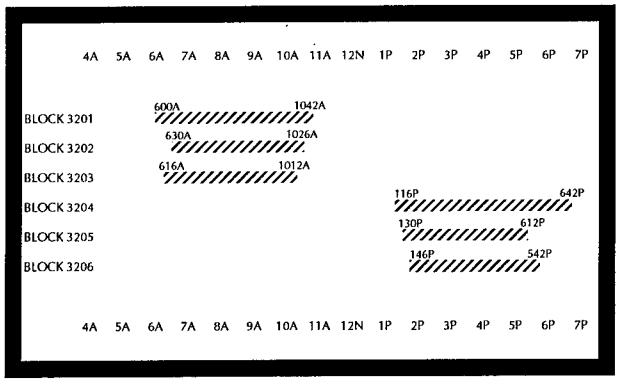
Trip #	ABC	DEF	GHI	JKL
1W	6:36			
2W	6:58			
3W	7:30			

Time point	A.M.
ABC	
DEF	9
GHI	6
JKL	7

CHAPTER 3

BLOCKING

Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
6:26	6:35	6:41	6:45	6:55	7:02							
6:56	7:05	7:11	7:15	7:25	7:32		6:10	6:17	6:27	6:31	6:37	6:46
7:26	7:35	7:41	7:45	7:55	8:02	A	6:40	6:47	6:57	7:01	7:07	7:16
7:56	8:05	8:11	8:15	8:25	8:32	M	7:10	7:17	7:27	7:31	7:37	7:46
8:26	8:35	8:41	8:45	8:55	9:02		7:40	7:47	7:57	8:01	8:07	8:16
8:56	9:05	9:11	9:15	9:25	9:32		8:10	8:17	8:27	8:31	8:37	8:46
9:26	9:35	9:41	9:45	9:55	10:02		8:40	8:47	8:57	9:01	9:07	9:16
9:56	10:05	10:11	10:15	10:25	10:32		9:10	9:17	9:27	9:31	9:37	9:46
							9:40	9:47	9:57	10:01	10:07	10:16
1:26	1:35	1:41	1:45	1:55	2:02							
1:56	2:05	2:11	2:15	2:25	2:32		1:40	1:47	1:57	2:01	2:07	2:16
2:26	2:35	2:41	2:45	2:55	3:02		2:10	2:17	2:27	2:31	2:37	2:46
2:56	3:05	3:11	3:15	3:25	3:32		2:40	2:47	2:57	3:01	3:07	3:16
3:26	3:35	3:41	3:45	3:55	4:02		3:10	3:17	3:27	3:31	3:37	3:46
3:56	4:05	4:11	4:15	4:25	4:32		3:40	3:47	3:57	4:01	4:07	4:16
4:26	4:35	4:41	4:45	4:55	5:02	P	4:10	4:17	4:27	4:31	4:37	4:46
4:56	5:05	5:11	5:15	5:25	5:32	M	4:40	4:47	4:57	5:01	5:07	5:16
4:26	4:35	4:41	4:45	4:55	5:02		5:10	5:17	5:27	5:31	5:37	5:46
5:56	6:05	6:11	6:15	6:25	6:32							



Study Objectives

1) Learn that blocking is the process of developing vehicle assignments.

2) Know why blocking is important.

3) Understand that agency work rules and policy regarding layover/recovery time, layover locations and interlining are necessary for proceeding with the blocking process.

4) Remember the definitions of (and difference between) layover and recovery time.

5) Learn that interlining allows one vehicle to operate trips on more than one route.

6) Understand why interlining is done.

7) Be able to block a simple schedule.

8) Be able to complete a blocking sheet for a simple schedule.

9) Be able to recognize a four digit blocking numbering convention.

10) Learn the block/trip number notation for noting block numbers on a master schedule.

11) Learn what "hooking" trips together means.

12) Learn the relationship between cost and the amount of recovery time built into a schedule.

13) Remember the simple formula for computing the number of vehicles needed to maintain a given level of service with a consistent headway.

14) Learn the benefits of maintaining slightly excessive layover/recovery time.

15) Understand why some inconsistencies will occur in headways, particularly during certain times of the day.

16) Be able to recognize and complete a block summary recap sheet.

17) Be able to graph blocks, given the appropriate trip information.

I. Introduction

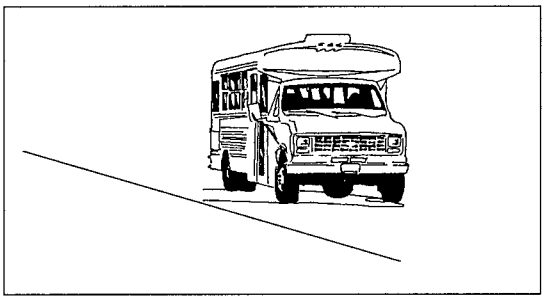
What is "blocking"?

Blocking is the process of developing vehicle assignments.

These assignments, or blocks, describe a series of trips that are "hooked" together and assigned to a single vehicle.

The vehicle trips that are linked together as part of the block may cover more than one route and may also involve more than one operator during the course of the vehicle workday.

However, the block refers to the work assignment for only a single vehicle for a single service workday.



A block is the work assignment for a single vehicle during a service work day.

Why is blocking important?

Blocking is a critical element in the scheduling process because it serves as the basis for both the costs associated with operating the revenue service vehicle as well as influencing the cost associated with work assignments for operators.

Setting up the blocking process

Before blocking can begin, the scheduler must have a completed master schedule for each route to be blocked.

The scheduler must also be thoroughly knowledgeable of all applicable company work rules related to blocking.

Three agency policies that have great impact on the blocking process are

- Layover and recovery time,
- Layover locations, and
- Interlining.

A thorough knowledge of work rules related to the runcutting process (assigning work to operators, see Chapter 4) will also help to optimize the efficiency of the blocking process.

Layover and recovery time

Layover and recovery are "out-of-service" time allowances allocated to a vehicle at a certain location or locations along the route, generally at a terminal location.

("In-service" time is when the vehicle is in revenue service, transporting passengers.)

Layover time is rest or "break" time allocated to the operator somewhere along the line, usually at a terminal location at the end of a trip. The minimum amount of layover time is usually determined by labor agreement or agency policy.

Layover time is often considered time due to the operator, like a break during an office or factory job.

Recovery time can be thought of as "buffer" break time built into the schedule. It may or may not be used by the operator. If the vehicle is behind schedule, it can often catch up to the schedule by not taking any of (or just a portion of) the scheduled recovery time. Recovery time also provides the operator additional time to change headsigns, make trip sheet entries or perform other duties.

Recovery time is distinct from layover time, although they are often taken together at the same location. Unlike layover time, recovery time is typically considered agency time and is allocated at the discretion of the agency.

About layover and recovery policy

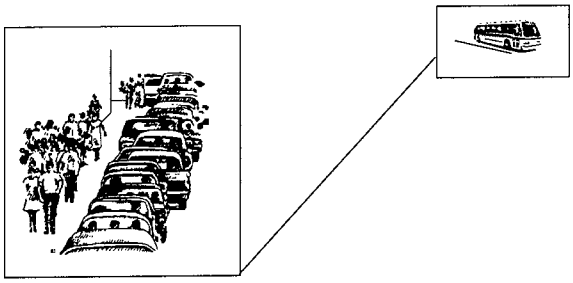
Layover and recovery policy may be determined by labor agreement, practice or agency standards. For optimal blocking, it is important to know whether the layover/ recovery policy represents a guideline that can be adjusted to optimize blocks, or is a hard and fast rule which must be followed even if it impacts blocking efficiency.

Often, layover time is required by contract, but recovery time can be adjusted depending on time of day and blocking needs.

One commonly used policy requires a minimum layover and recovery time of 10% of the total round trip running time.

Layover locations

Many agencies have, by practice or work rules, limited the locations where layover and recovery can be taken. For example, on radial routes serving a congested downtown area, layover is often taken at the outer ends of the route only.



Layover is often taken at the outer end(s) of a route serving a congested downtown area.

In some cases, layover is required on both ends of a route depending on the length of the route and the location of the terminals.

Layover and recovery must be taken in a safe location where a vehicle can stand still without impeding traffic. Layover and recovery is generally taken at the end of the line (terminal) where it will inconvenience the fewest passengers. However, it may also be assigned at key transfer points such as rail stations.

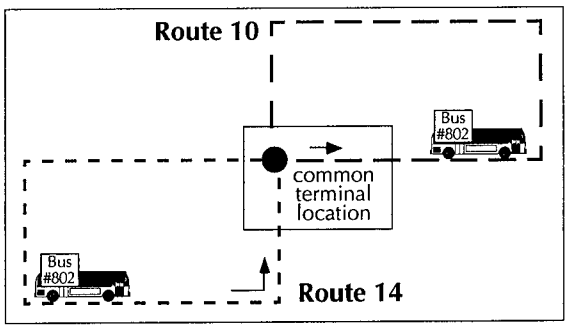
Interlining

What is interlining again?

Interlining assigns a vehicle to operate trips on more than one route.

Interlining is sometimes done to optimize blocking, however, it is also done as a convenience to the passengers.

For example, if many passenger trips that originate on one route are destined for a location or locations on a second route that shares a common terminal location with the first route, interlining will allow those passengers to reach their destination without transferring to another vehicle.



Interlining allows the use of the same vehicle on more than one route or line.

Vehicles may typically travel between one route and another only once or only occasionally during the service day. For example, a vehicle may provide peak service on one route and then begin providing midday service on another route.

More complex interlining may involve a block that alternates between routes throughout the entire service day. These complex interlines generally occur at a common terminal point or points.

Transit agencies often have policies regarding the amount of interlining that can occur and where interlining can be scheduled.

Policy knowledge is a must.

Review key points by answering these questions.

1) Blocking is the process of developing vehicle assignments. True or False

2) A block may refer to more than one vehicle. True or False

3) Blocking is a critical element in the scheduling process because it influences both the costs associated with vehicle assignments and the cost associated with operator assignments. True or False

4) It is not necessary to have a completed master schedule for a route for blocking to begin. True or False

5) A thorough knowledge of work rules related to the runcutting process will also help to optimize the efficiency of the blocking process. True or False

6) _ _ _ _ _ _ _ and _ _ _ _ _ _ _ _ are out-of-service time allowances allocated to a vehicle at a certain location or locations along the route, generally at a terminal point.

7) Recovery time is distinct from layover time, although they are often combined. True or False

8) Often, _____ time is required by contract, but _____ time can be adjusted depending on time of day and blocking needs.

9) Match the following:

Layover time	considered time due the operator
Recovery time	generally allocated at the discretion of the agency
	buffer time
	labor agreement

10) On radial routes serving a congested downtown, layover is often taken...

a) at outer ends
b) at inner ends
c) in western locations
d) none of the above

11) _ _ _ _ _ _ _ _ _ _ _ assigns a vehicle to operate trips on more than one route.

II. Basic Blocking Exercise

In preparing for blocking, the scheduler typically needs the following information:

1) Master schedule for route
2) Layover/recovery time policy
3) Layover locations
4) Interlining policy
5) Other applicable work rules

This information is provided below for Route 32.

Westbound							Eastbound						
Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
6:26	6:35	6:41	6:45	6:55	7:02							
6:56	7:05	7:11	7:15	7:25	7:32		6:10	6:17	6:27	6:31	6:37	6:46
7:26	7:35	7:41	7:45	7:55	8:02	A	6:40	6:47	6:57	7:01	7:07	7:16
7:56	8:05	8:11	8:15	8:25	8:32	M	7:10	7:17	7:27	7:31	7:37	7:46
8:26	8:35	8:41	8:45	8:55	9:02		7:40	7:47	7:57	8:01	8:07	8:16
8:56	9:05	9:11	9:15	9:25	9:32		8:10	8:17	8:27	8:31	8:37	8:46
9:26	9:35	9:41	9:45	9:55	10:02		8:40	8:47	8:57	9:01	9:07	9:16
9:56	10:05	10:11	10:15	10:25	10:32		9:10	9:17	9:27	9:31	9:37	9:46
							9:40	9:47	9:57	10:01	10:07	10:16
1:26	1:35	1:41	1:45	1:55	2:02							
1:56	2:05	2:11	2:15	2:25	2:32		1:40	1:47	1:57	2:01	2:07	2:16
2:26	2:35	2:41	2:45	2:55	3:02		2:10	2:17	2:27	2:31	2:37	2:46
2:56	3:05	3:11	3:15	3:25	3:32		2:40	2:47	2:57	3:01	3:07	3:16
3:26	3:35	3:41	3:45	3:55	4:02		3:10	3:17	3:27	3:31	3:37	3:46
3:56	4:05	4:11	4:15	4:25	4:32	P	3:40	3:47	3:57	4:01	4:07	4:16
4:26	4:35	4:41	4:45	4:55	5:02	M	4:10	4:17	4:27	4:31	4:37	4:46
4:56	5:05	5:11	5:15	5:25	5:32		4:40	4:47	4:57	5:01	5:07	5:16
4:26	4:35	4:41	4:45	4:55	5:02		5:10	5:17	5:27	5:31	5:37	5:46
5:56	6:05	6:11	6:15	6:25	6:32							

Master schedule for Route 32

Layover/recovery time policy:

Minimum Layover/Recovery Time Allowance Table

ROUND TRIP RUNNING TIME (excluding layover/recovery time)	LAYOVER/RECOVERY TIME	MINIMUM % OF RUNNING TIME
Up to 60 minutes	0 - 6 minutes	10%
61 to 120 minutes	6 - 12 minutes	10%
121 to 180 minutes	12 - 18 minutes	10%

Layover/recovery time may be taken at either terminal and may be divided between terminals.

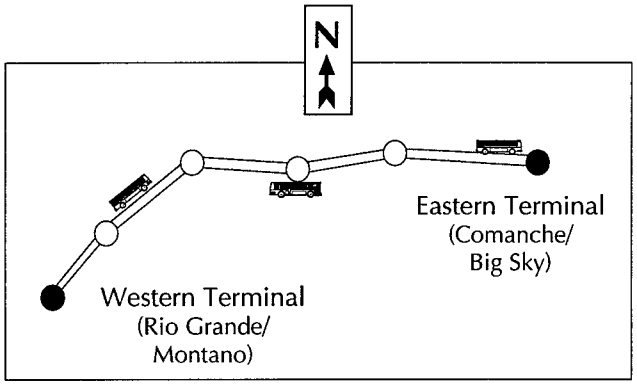
Layover locations: Both the western and eastern terminals.

Interlining policy: Because only one route is being blocked, no interlining will take place.

Work rules: No restrictions apply.

Some notes about the master schedule for Route 32

This schedule is based on a company policy of a 30-minute headway. This means that a vehicle is scheduled to come by any given location on the route every 30 minutes.



With this schedule on Route 32, A.M. WEEKDAY service begins at the western terminal at 6:10 a.m. and ends again at same location at 10:32 a.m. No service is available on this route again until 1:26 p.m. when it begins at the eastern terminal and ends at the western terminal at 6:32 p.m.

A blocking sheet is often used to track blocks as they are created. A sample blocking sheet is shown on the next page.

Pull-out

Pull-out refers to the time that a revenue service vehicle is scheduled to leave the vehicle storage facility and travel to the point on the route where revenue service begins.

For Route 32, the pull-out times are listed on the Pull-out and Pull-in Allowance table shown below.

Pull-in

Conversely, pull-in refers to the time the revenue service vehicle is scheduled to pull-in to the vehicle storage facility after completing revenue service.

For Route 32, pull-in times are also shown below.

Route 32 Pull-out and Pull-in Allowances

Terminal	Pull-out		Pull-in	
Comanche & Big Sky	Weekday Saturday Sunday	:10 No Svc. No Svc.	Weekday Saturday Sunday	:10 No Svc. No Svc.
Rio Grande & Montano	Weekday Saturday Sunday	:10 No Svc. No Svc.	Weekday Saturday Sunday	:10 No. Svc. No. Svc.

BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

Scheduler: BWN

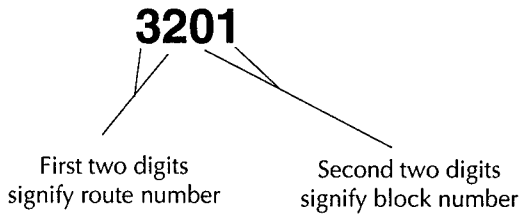
Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	Pull-out	Trip #	Depart Eastern Terminal	Arrive Western Terminal	Available for next trip (Arrival + Layover)	Trip #	Depart Western Terminal	Arrive Eastern Terminal	Available for next trip (Arrival + Layover)	Pull-in
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		

Block numbering conventions

Transit agencies use a variety of numbering conventions for blocks. Many agencies use four digit numbers, where the first two digits are the route number and the second two digits are the block number. Using this convention for Route 32, the first block would be 3201.



Layover/recovery allowance table

How much layover/recovery time should I use on this route?

The layover policy allocates layover/recovery time as a minimum percentage of the round trip running time.

Example Layover/Recovery Time Allowance Table

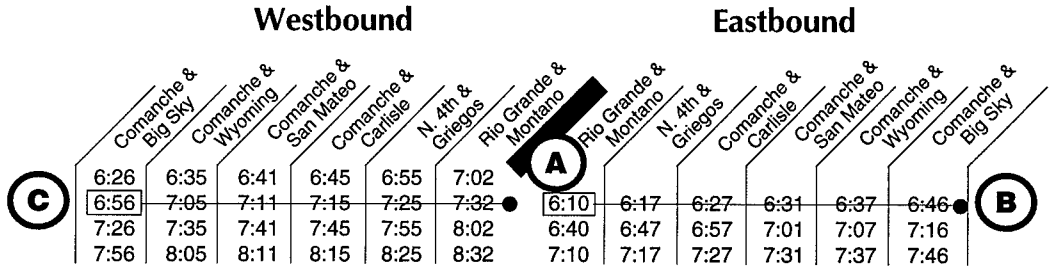
ROUND TRIP RUNNING TIME (excluding layover/recovery time)	LAYOVER/RECOVERY TIME	MINIMUM % OF RUNNING TIME
Up To 60 minutes	0 - 6 minutes	10%
61 to 120 minutes	6 - 12 minutes	10%
121 to 180 minutes	12 - 18 minutes	10%

The layover/recovery allowance table indicates that for a round trip running time of up to 120 minutes, a minimum of 10% of the running time is required for layover/recovery. 72 minutes x 10% = 7.2, rounded up to 8 minutes. However, this agency has determined that operating a consistent and fixed 30-minute headway results in 18 minutes of layover/recovery per round trip (see Chapter 2/ Trip Generation). Eight minutes will be assigned at the western terminal (Rio Grande & Montano) and 10 minutes will be assigned at the eastern terminal (Comanche & Big Sky).

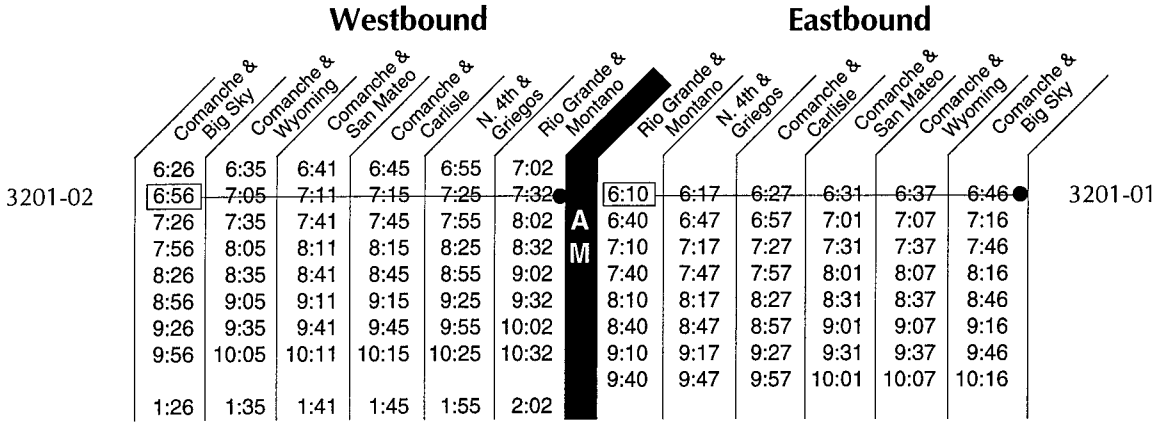
The blocking process

The first block, 3201, pulls-out from the garage and travels without passengers (deadheads) to the western terminal and begins passenger service from there at 6:10. (A) 3201 arrives at the eastern terminal at 6:46. (B) With the required 10 minutes layover/recovery time at the eastern terminal, 3201 would be available for its next trip at 6:56 (6:46 plus 10 minutes).

The next westbound trip on the master schedule leaves Comanche & Big Sky at 6:56. (C) This will be the next trip for block 3201.



It is helpful to note the trip numbers for each block on a copy of the master schedule for the route to help ensure that all trips are blocked. For Route 32 below, the block will be the first number (3201-01) and the trip will be the second number (3201-01). 3201-02 is the second trip for block 3201.



The blocking sheet

The blocking sheet is a tool to help the scheduler document the trip start and end times associated with each vehicle.

BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

Scheduler: BWN

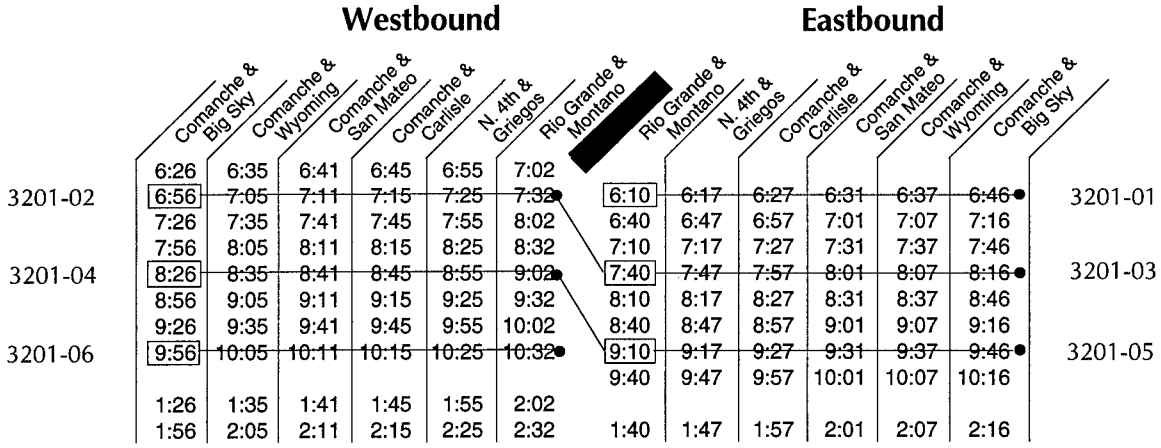
Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3201 3201	6:00	02	6:56	7:32	7:40	01	6:10	6:46	6:56	

"Hooking" trips together

The blocking process continues with hooking more trips on to 3201. Diagramming the hooks (colored pencils are a helpful tool) facilitates the process. Note that trip 3201-02 starts from Comanche & Big Sky at 6:56 and ends at Rio Grande & Montano at 7:32. After a layover from 7:32 to 7:40 (8 minutes), block 3201 begins trip 03 at 7:40, and so on until trip 3201-06 is completed at 10:32.



	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky	
	6:26	6:35	6:41	6:45	6:55	7:02								
3201-02	6:56	7:05	7:11	7:15	7:25	7:32		6:10	6:17	6:27	6:31	6:37	6:46	3201-01
	7:26	7:35	7:41	7:45	7:55	8:02		6:40	6:47	6:57	7:01	7:07	7:16	
	7:56	8:05	8:11	8:15	8:25	8:32		7:10	7:17	7:27	7:31	7:37	7:46	
3201-04	8:26	8:35	8:41	8:45	8:55	9:02		7:40	7:47	7:57	8:01	8:07	8:16	3201-03
	8:56	9:05	9:11	9:15	9:25	9:32		8:10	8:17	8:27	8:31	8:37	8:46	
	9:26	9:35	9:41	9:45	9:55	10:02		8:40	8:47	8:57	9:01	9:07	9:16	
3201-06	9:56	10:05	10:11	10:15	10:25	10:32		9:10	9:17	9:27	9:31	9:37	9:46	3201-05
								9:40	9:47	9:57	10:01	10:07	10:16	
	1:26	1:35	1:41	1:45	1:55	2:02								
	1:56	2:05	2:11	2:15	2:25	2:32		1:40	1:47	1:57	2:01	2:07	2:16	

After 10:32 a.m., there are no additional hooks for 3201. If this block were to stay in service on this route, it would have to wait at the terminal until 1:40 p.m. Since this is not practical and the block will not be interlined onto another route, the vehicle operating this block will return to the garage. The blocking sheet below summarizes the information for the additional trips on block 3201.

BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

Scheduler: BWN

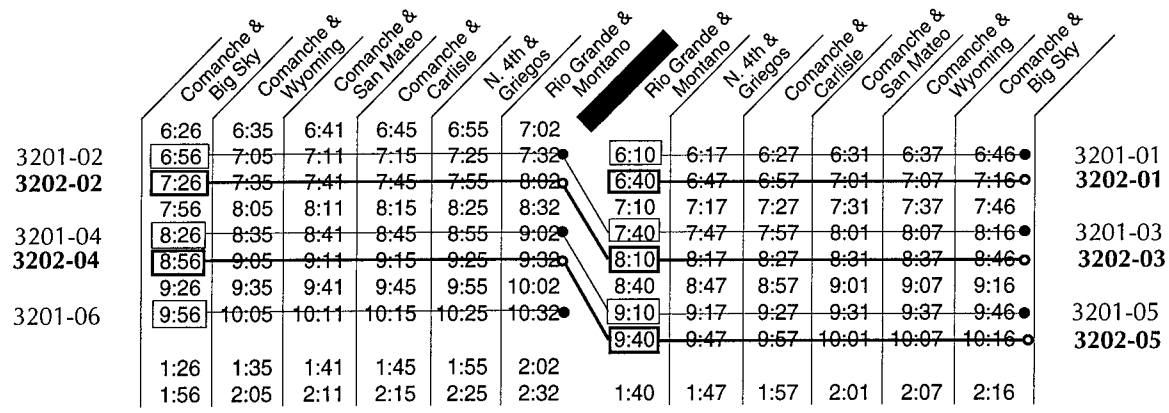
Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3201	6:00					01	6:10	6:46	6:56	
3201		02	6:56	7:32	7:40	03	7:40	8:16	8:26	
3201		04	8:26	9:02	9:10	05	9:10	9:46	9:56	
3201		06	9:56	10:32						10:42

Completing the A.M. blocks

Blocking 3202 continues in the same way, beginning with the 6:40 trip (**3202-01**) from the western terminal at Rio Grande & Montano and ending with the 9:40 trip (**3202-05**) to Comanche & Big Sky, arriving at 10:16.



	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano	Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky	
	6:26	6:35	6:41	6:45	6:55	7:02							
3201-02	6:56	7:05	7:11	7:15	7:25	7:32	6:10	6:17	6:27	6:31	6:37	6:46	3201-01
3202-02	7:26	7:35	7:41	7:45	7:55	8:02	6:40	6:47	6:57	7:01	7:07	7:16	**3201-01**
	7:56	8:05	8:11	8:15	8:25	8:32	7:10	7:17	7:27	7:31	7:37	7:46	
3201-04	8:26	8:35	8:41	8:45	8:55	9:02	7:40	7:47	7:57	8:01	8:07	8:16	3201-03
3202-04	8:56	9:05	9:11	9:15	9:25	9:32	8:10	8:17	8:27	8:31	8:37	8:46	**3202-03**
	9:26	9:35	9:41	9:45	9:55	10:02	8:40	8:47	8:57	9:01	9:07	9:16	
3201-06	9:56	10:05	10:11	10:15	10:25	10:32	9:10	9:17	9:27	9:31	9:37	9:46	3201-05
							9:40	9:47	9:57	10:01	10:07	10:16	**3202-05**
	1:26	1:35	1:41	1:45	1:55	2:02							
	1:56	2:05	2:11	2:15	2:25	2:32	1:40	1:47	1:57	2:01	2:07	2:16	

COMPLETE THE ABOVE SCHEDULE FOR BLOCK 3203,
THEN COMPLETE THE BLOCKING SHEET BELOW FOR 3203
(answers are on the next page)

BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

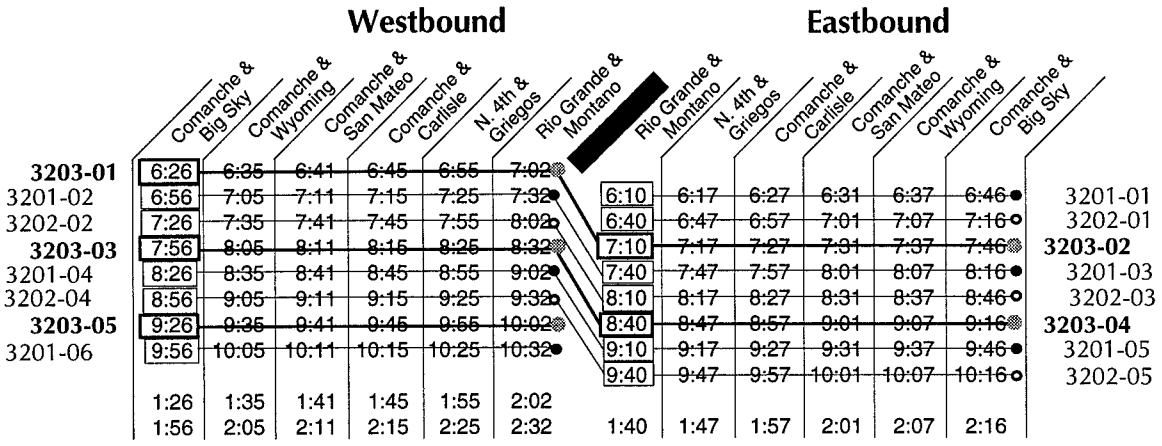
Scheduler: BWN

Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3201	6:00					01	6:10	6:46	6:56	
3201		02	6:56	7:32	7:40	03	7:40	8:16	8:26	
3201		04	8:26	9:02	9:10	05	9:10	9:46	9:56	
		06	9:56	10:32						10:42
3202	6:30					01	6:40	7:16	7:26	
3202		02	7:26	8:02	8:10	03	8:10	8:46	8:56	
3202		04	8:56	9:32	9:40	05	9:40	10:16		10:26
3203										

Completing the A.M. blocks (answers to the previous page exercise)



BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

Scheduler: BWN

Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3201	6:00					01	6:10	6:46	6:56	
3201		02	6:56	7:32	7:40	03	7:40	8:16	8:26	
3201		04	8:26	9:02	9:10	05	9:10	9:46	9:56	
		06	9:56	10:32						10:42
3202	6:30					01	6:40	7:16	7:26	
3202		02	7:26	8:02	8:10	03	8:10	8:46	8:56	
3202		04	8:56	9:32	9:40	05	9:40	10:16		10:26
3203	**6:16**	**01**	**6:26**	**7:02**	**7:10**	**02**	**7:10**	**7:46**	**7:56**	
3203		**03**	**7:56**	**8:32**	**8:40**	**04**	**8:40**	**9:16**	**9:26**	
3203		**05**	**9:26**	**10:02**						**10:12**

Some notes about the blocking process

Layover/recovery time allowance

Recovery time should not be viewed as a way to guarantee that all trips are on time all the time. This level of guarantee would require higher operator labor costs and more vehicles to operate the same level of service.

How is recovery time related to costs?

Excessive recovery time increases the number of vehicles and operators required to operate a given service. Again, to calculate the number of vehicles required to operate a given service, the following formula can be used:

$$\textbf{\# Vehicles} = \frac{\text{Cycle time}}{\text{Headway}}$$

Cycle time = running time + layover/ recovery time

Headway = time between vehicles travelling in the same direction at a given location

Formula for computing the number of vehicles needed to operate a given service.

For example, if a route has a running time of **54** minutes plus *6* minutes for layover/ recovery and a headway of **10** minutes, then the formula shows a need for 6 vehicles.

$$\textbf{6} = \frac{(54 + 6) = 60}{10}$$

However, if the layover/recovery time is increased to *16* minutes, then the number of needed vehicles increases.

$$\textbf{7} = \frac{(54 + 16) = 70}{10}$$

Obviously, a layover/recovery of 6 minutes versus 16 is more economical in terms of fewer vehicles and, most likely, fewer operators.

Is there any benefit to having slightly excessive layover/recovery time?

As noted in Chapter 2/ Trip Generation, extra layover time may be assigned when clock headways are developed as a convenience to customers. For example, customers know that vehicles come along every 5 , 10 or 30 minutes past the hour. Route 32 provides that type of service by maintaining a 30-minute headway.

Also, timed transfers sometime result in the need for extra layover/recovery time so that trips arrive and leave at precisely the same time. Master schedule development and blocking are often a balance between cost-effectiveness and responding to customer service needs.

In cases where excessive layover/recovery time does exist after a trip, it may be possible to hook on another trip. These are opportunities that schedulers continually evaluate.

In the example of Route 32, two A.M. blocks begin at the western terminal and one begins at the eastern terminal. Why?

While initiating the blocking process by beginning with the first inbound trip to downtown tends to be a convention, vehicles are often sent out to both ends of a route to begin the service day. When peak service is provided from an outer terminal into a downtown area, it is more common to send vehicles primarily to the outer terminal at the start of A.M. service and to the inner terminal at the start of P.M. service.

Do many schedules maintain a consistent headway throughout the day?

Even with schedules that are very consistent with fixed headways, the last trip or two of the day is often inconsistent with the headway pattern for a variety of reasons. One important reason is the desire to include a slight delay in the start times of the last trips on a route in order to allow the maximum number of passengers the opportunity to catch the final trip(s).

COMPLETE THE SCHEDULE NOTATIONS AND BLOCKING SHEET BELOW
FOR THE P.M. BLOCKS OF ROUTE 32
(answers are on the next page)

Westbound

	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano
	6:26	6:35	6:41	6:45	6:55	7:02
	6:56	7:05	7:11	7:15	7:25	7:32
	7:26	7:35	7:41	7:45	7:55	8:02
	7:56	8:05	8:11	8:15	8:25	8:32
	8:26	8:35	8:41	8:45	8:55	9:02
	8:56	9:05	9:11	9:15	9:25	9:32
	9:26	9:35	9:41	9:45	9:55	10:02
	9:56	10:05	10:11	10:15	10:25	10:32
3204-01	1:26	1:35	1:41	1:45	1:55	2:02
	1:56	2:05	2:11	2:15	2:25	2:32
	2:26	2:35	2:41	2:45	2:55	3:02
3204-03	2:56	3:05	3:11	3:15	3:25	3:32
	3:26	3:35	3:41	3:45	3:55	4:02
	3:56	4:05	4:11	4:15	4:25	4:32
	4:26	4:35	4:41	4:45	4:55	5:02
	4:56	5:05	5:11	5:15	5:25	5:32
	5:26	5:35	5:41	5:45	5:55	6:02
	5:56	6:05	6:11	6:15	6:25	6:32

Eastbound

	Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
	6:10	6:17	6:27	6:31	6:37	6:46
	6:40	6:47	6:57	7:01	7:07	7:16
	7:10	7:17	7:27	7:31	7:37	7:46
	7:40	7:47	7:57	8:01	8:07	8:16
	8:10	8:17	8:27	8:31	8:37	8:46
	8:40	8:47	8:57	9:01	9:07	9:16
	9:10	9:17	9:27	9:31	9:37	9:46
	9:40	9:47	9:57	10:01	10:07	10:16
	1:40	1:47	1:57	2:01	2:07	2:16
3204-02	2:10	2:17	2:27	2:31	2:37	2:46
	2:40	2:47	2:57	3:01	3:07	3:16
	3:10	3:17	3:27	3:31	3:37	3:46
3204-04	3:40	3:47	3:57	4:01	4:07	4:16
	4:10	4:17	4:27	4:31	4:37	4:46
	4:40	4:47	4:57	5:01	5:07	5:16
	5:10	5:17	5:27	5:31	5:37	5:46

AM / PM

BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

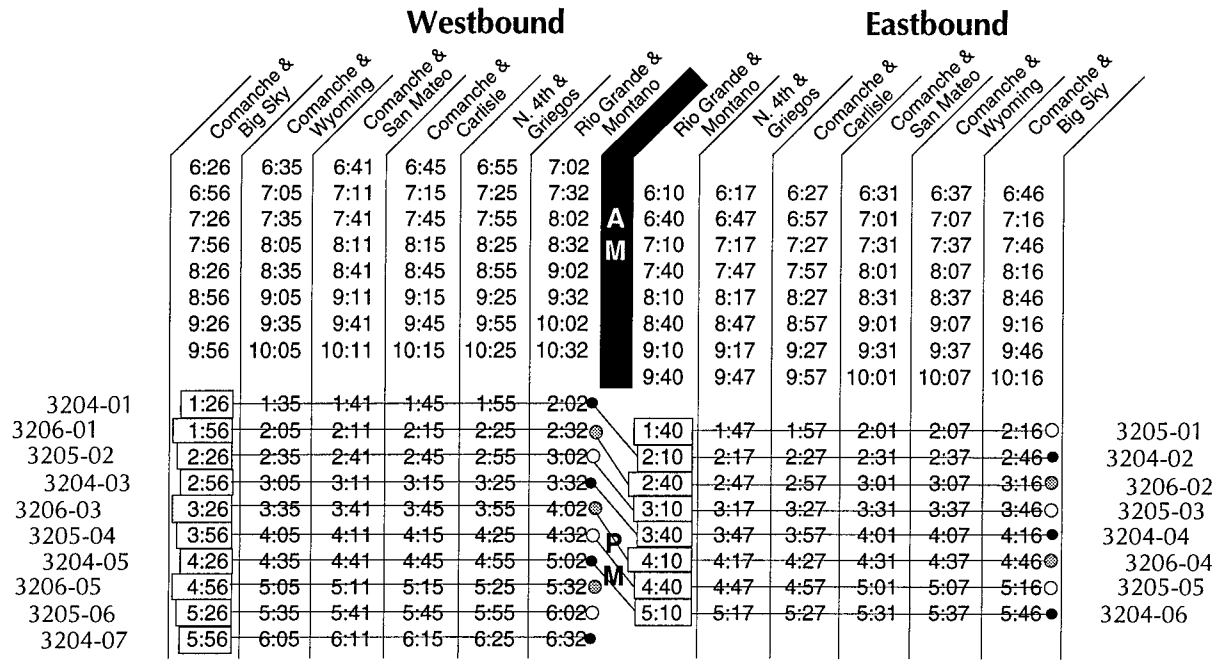
Scheduler: BWN

Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3204	1:16	01	1:26	2:02	2:10	02	2:10	2:46	2:56	
3204		03	2:56	3:32	3:40	04	3:40	4:16	4:26	
3204		05				06				
3204		07								___
3205										
3205										
3205										
3205										___
3206										
3206										
3206										___

Completing the P.M. blocks (answers from previous page exercise)



BLOCKING SHEET

Route #: 32

Service: WEEKDAYS

Date: 10/20/XX

Scheduler: BWN

Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

Westbound						Eastbound				
Block No.	**Pull-out**	**Trip #**	**Depart Eastern Terminal**	**Arrive Western Terminal**	**Available for next trip (Arrival + Layover)**	**Trip #**	**Depart Western Terminal**	**Arrive Eastern Terminal**	**Available for next trip (Arrival + Layover)**	**Pull-in**
			Comanche/ Big Sky	Rio Grande/ Montano			Rio Grande/ Montano	Comanche/ Big Sky		
3204	1:16	01	1:26	2:02	2:10	02	2:10	2:46	2:56	
3204		03	2:56	3:32	3:40	04	3:40	4:16	4:26	
3204		05	4:26	5:02	5:10	06	5:10	5:46	5:56	
3204		07	5:56	6:32						6:42
3205	1:30					01	1:40	2:16	2:26	
3205		02	2:26	3:02	3:10	03	3:10	3:46	3:56	
3205		04	3:56	4:32	4:40	05	4:40	5:16	5:26	
3205		06	5:26	6:02						6:12
3206	1:46	01	1:56	2:32	2:40	02	2:40	3:16	3:26	
3206		03	3:26	4:02	4:10	04	4:10	4:46	4:56	
3206		05	4:56	5:32						5:42

Block summary recap

The blocks created for Route 32 can now be further summarized on a block summary recap form as shown below. This form shows only the first trip and the last trip of each block for the one route.

Platform hours denote the amount of time an operator is scheduled to be behind the wheel of the vehicle, including Pull-In and Pull-Out times. Pull-In and Pull-Out times are not generally included in Revenue Service time unless the vehicle is actually available for passenger service during those times.

BLOCK SUMMARY RECAP

Route #: 32 - Griegos-Comanche
Service: WEEKDAYS
Date: 10/27/XX
Scheduler: BWN

Special Instructions:

18 minutes is available for layover and/or recovery per round trip. OK to split the layover and/or recovery between ends of the line.

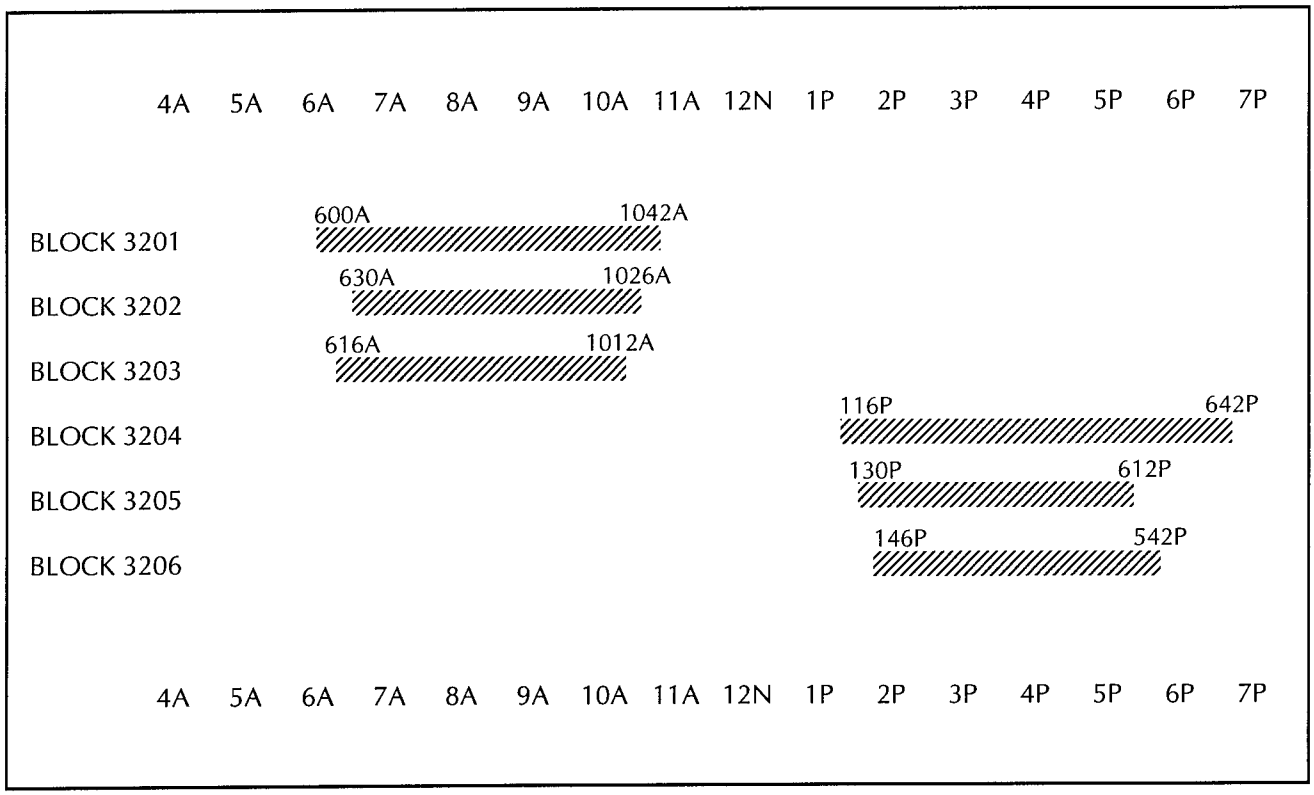
BLOCK #	PULL-OUT TIME (Time out)	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME (Time in)
3201	6:00A	Rio Grande/ Montano	6:10A	10:32A	Rio Grande/ Montano	10:42A
Platform Hours			**4:42**			
3202	6:30A	Rio Grande/ Montano	6:40A	10:16A	Comanche/ Big Sky	10:26A
Platform Hours			**3:56**			
3203	6:16A	Comanche/ Big Sky	6:26A	10:02A	Rio Grande/ Montero	10:12A
Platform Hours			**3:56**			
3204	1:16P	Comanche/ Big Sky	1:26P	6:32P	Rio Grande/ Montano	6:42P
Platform Hours			**5:26**			
3205	1:30P	Rio Grande/ Montano	1:40P	6:02P	Rio Grande/ Montano	6:12P
Platform Hours			**4:42**			
3206	1:46P	Comanche/ Big Sky	1:56P	5:32P	Rio Grande/ Montano	5:42P
Platform Hours			**3:56**			
TOTAL PLATFORM HOURS			**26:38**			

Graphing the Blocks

Blocks are often displayed graphically to illustrate the time spans that the blocks are in service. Time spans (in this case, platform time) can be obtained from the block summary recap.

This type of graphic display is especially valuable as a tool for runcutting.

An example of a graphic display of Route 32 is shown below.



Review key points by answering these questions.

1) Match the following:

Pull-In	The time a vehicle is scheduled to leave the storage facility
Pull-Out	The time a vehicle is scheduled to arrive at the storage facility

2) A Blocking Sheet is often used to track blocks as they are created. True or False

3) If the 4-digit number below was a numbering convention for blocking, the two numbers on the right would typically refer to the trip number. True or False

   1204

4) It is helpful to note the trip numbers for each block on a copy of the master sheet for the route to help ensure that

   a) all trips are blocked
   b) pull-out time is correct
   c) enough recovery time is allowed
   d) blocks are graphically displayed

5) Recovery time should not be viewed as a way to guarantee that all trips are on time all the time. True or False

6) Excessive recovery time increases / decreases the number of vehicles (and sometimes operators) required to operate a given level of service. (choose one)

7) Extra recovery time is often given by agencies to produce even (or clock) headways as a convenience to customers. True or False

8) In cases where excessive layover time may result after a particular trip, it may be possible to hook on another trip. True or False

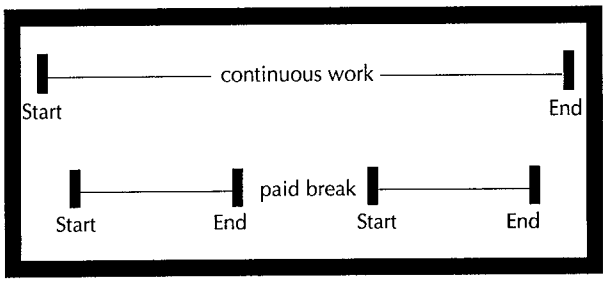
9) Beginning blocking with the first inbound trip to downtown is considered a convention. True or False

10) What is one reason that one or more trips may be planned with an inconsistent headway while most trips on the route maintain a fixed headway?

11) Graphic block displays generally depict revenue service vehicle platform hours. True or False

CHAPTER 4

RUNCUTTING



SPLIT RUN

Report Allowance	:10
Pull-Out Allowance	:23
Revenue Time	5:00
Pull-In Allowance	:21
Turn-In Allowance	:05
Report Allowance	:10
Pull-Out Allowance	:15
Revenue Time	1:28
Pull-In Allowance	:13
Turn-In Allowance	:05
Total Platform & Collaterals	8:10
Make-Up Time	:00
Pay Hours	8:10
OT Pay	:05
Total Pay Hours	8:15

A.M BLOCKS		P.M. BLOCKS	
3201 6:00am	4:42 10:42am	3206 1:46pm	3:56 5:42pm
3203 6:16am	3:56 10:12am	3205 1:30pm	4:42 6:12pm
3202 6:30am	3:56 10:26am	3204 1:16pm	5:26 6:42pm
Total A.M Platform	12:34	Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS Effective: 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull Out	Pull In	Time Off	2nd Piece Block	Route	Time On	Pull Out	Pull In	Time Off	Platform	Total Spread	Allowance Report	Turn In	Relief	Make Up	Work Hours	Over Time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1042p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08	:34	:14	9:56
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08	:34	:21	10:03
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52	:56	:29	11:17
TOTALS													26:38 Platform		1:00 Allowance Report	:30 Turn In	0 Relief	0 Make Up	28:08 Work Hours	2:04 Over Time	1:04 Spread Penalty	31:16 Pay Hours

Study Objectives

1) Learn that runcutting is the process of developing operator (driver) assignments.

2) Be able to recognize the difference between straight runs and split runs.

3) Remember that swing time is an unpaid break in a split run.

4) Understand that runcutting is critical because it defines the number of operators ultimately needed to operate the service reflected in the Master Schedule(s).

5) Recognize that before cutting runs, a scheduler must have a completed master schedule, blocking sheet and block summary recap for each route.

6) Learn the concept, definition and applicability of minimum and maximum platform time.

7) Learn the concept, definition and applicability of report and turn-in allowances.

8) Learn the concept, definition and applicability of spread time and spread penalty.

9) Learn the concept, definition and applicability of run type percentages.

10) Learn the concept, definition and applicability of make-up time.

11) Be able to identify the components of a run visualization diagram.

12) Remember the equation for estimating the number of runs that can be cut from a pool of blocks.

13) Understand the design and listing order of the chronological block listing.

14) Be able to give reasons for optimization.

15) Remember that the Run Guide can be a valuable resource for operator bids as well as provide useful information for some payroll accounting systems.

16) Be able to define the purpose of each column in a representative Run Guide.

17) Given applicable information, be able to cut runs.

I. Introduction

What is "runcutting"?

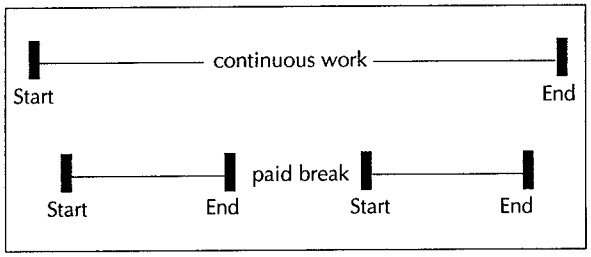
Runcutting is the process of developing operator (driver) assignments.

These assignments, called "runs" are assembled or "cut" from the vehicle assignments (blocks). (See Chapter 3.) Runs consist of one or more complete or partial blocks.

These blocks are cut and assembled in such a way as to create either straight runs or split (multi-piece) runs.

Straight runs

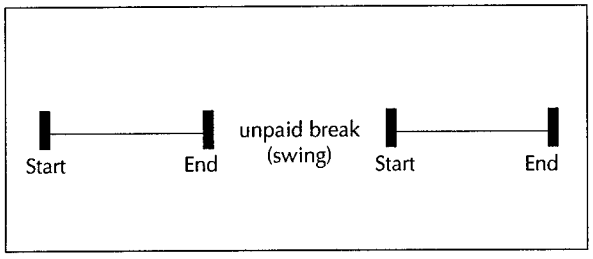
Straight runs imply continuous work of longer duration. A straight run generally consists of a single block piece of work close to eight hours long or more. A straight run can also consist of two block pieces with a paid break (usually under 60 minutes) in between.



Examples of straight runs

Split runs

A split run generally consists of two (sometimes three) block pieces with an unpaid break (often called swing time) in between. The operator is off-duty during the swing.



Example of a split run

Why is runcutting important?

Whereas efficient blocking is important in terms of vehicle utilization, runcutting is critical because it defines the number of operators ultimately needed to operate the service reflected in the Master Schedule(s).

Schedulers will often have to bring to bear all their skill and creativity in assigning all of the block pieces to the fewest number of operator runs possible.

Runs that adhere to all relevant work rules and policy guidelines are often called "legal" runs.

II. Setting up the Runcutting Process

Before beginning the runcutting process, the scheduler typically gathers a completed master schedule (Chapter 2), blocking sheet and block summary recap (Chapter 3) for each route.

Again, the scheduler must also be thoroughly knowledgeable of all applicable work rules and agency policies that affect or influence the runcutting process.

Although a diversity of work rules relating to scheduling can be found in the transit industry, five (5) will be exemplified and made applicable to the runcutting exercise for this chapter. Again, Route 32 will serve as the foundation for this section.

The five work rules applicable to the runcutting exercise for Route 32 are

- Minimum and Maximum Platform Time,
- Report and Turn-in Allowances,
- Spread Time and Spread Penalty,
- Run Type Percentages, and
- Make-up Time.

Each of these areas is covered on the following pages.

Minimum and maximum platform time

This work rule defines the minimum and maximum allowable length of each run as measured by platform time. Again, platform time is the total time during which an operator is scheduled to be behind the wheel of a vehicle in both revenue and non-revenue service. Another variation of minimum/maximum rules applies to pay hours. This variation considers the minimum or maximum amount of time an operator may be paid.

Platform time also includes any "pull-out" and "pull-in" allowance. These allowances, commonly referred to as "deadhead" times, are non-revenue time assigned for the movement of a revenue vehicle to the first scheduled stop (pull-out) and from the last scheduled stop back to the garage (pull-in).

At many agencies, block pieces that cannot be assembled into runs of minimum platform are generally arranged into pieces of work for part-time operators or assigned to the Extra Board (a contingency of operators who stand by or fill in for other operators).

Work Rule	For Route 32, the minimum platform time for a legal run is 6 hours. The maximum platform time for a legal run is 9.5 hours.

Report and turn-in allowances

The report allowance is an amount of time paid to an operator, starting when the operator reports for duty and ending when the pull-out time begins. During this paid time, the operator obtains instructions and supplies pertinent to the run, locates the assigned vehicle, performs a pre-trip inspection of the vehicle and tends to any other required duties before taking the vehicle onto the street.

The turn-in allowance is paid time for the operator to report to the dispatcher at the conclusion of the run (when pull-in time ends) for turning in transfers, receipts, supplies, reports and to tend to any other required duties after leaving the vehicle.

Work Rule	For Route 32, a 10-minute report allowance and a 5-minute turn-in allowance will apply for each piece of work.

Spread time and penalty

Spread time is generally defined as the total elapsed time between the first report time and the final turn-in time of a run. Spread time typically applies to split runs and, depending on the agency, varies between 10 and 14 hours in duration.

Spread penalty is an amount of pay granted to an operator for all minutes worked over a specified spread time.

Work Rule	For Route 32, the maximum allowed spread time is 13 hours. The spread penalty will be one half of all minutes over 11:30 spread time paid at straight time. Overtime will not be paid on spread minutes.

Run type and percentages

Many agencies are required to develop a certain percentage of straight runs and/or restrict the number of split runs. Usually, the restriction on split runs defines a certain percentage of splits that can exceed given levels of spread times.

For example, an agency may restrict run type and percentages as follows:

- 50% of all runs must be straight.
- Of the remaining 50%, 1/3 must be completed within 12:00 spread, 1/3 must be completed within 12:30 spread, and no more than 1/3 must be completed within 13:00 spread.

Work Rule	For Route 32, 60% of all blocks in revenue service at 11:00 a.m. must be cut to include a minimum of one straight run.
Work Rule	1/3 of all split runs must be completed within 12:00 spread time and 1/3 within 12:30. The remaining 1/3 must be completed within the maximum allowed spread of 13:00 hours.

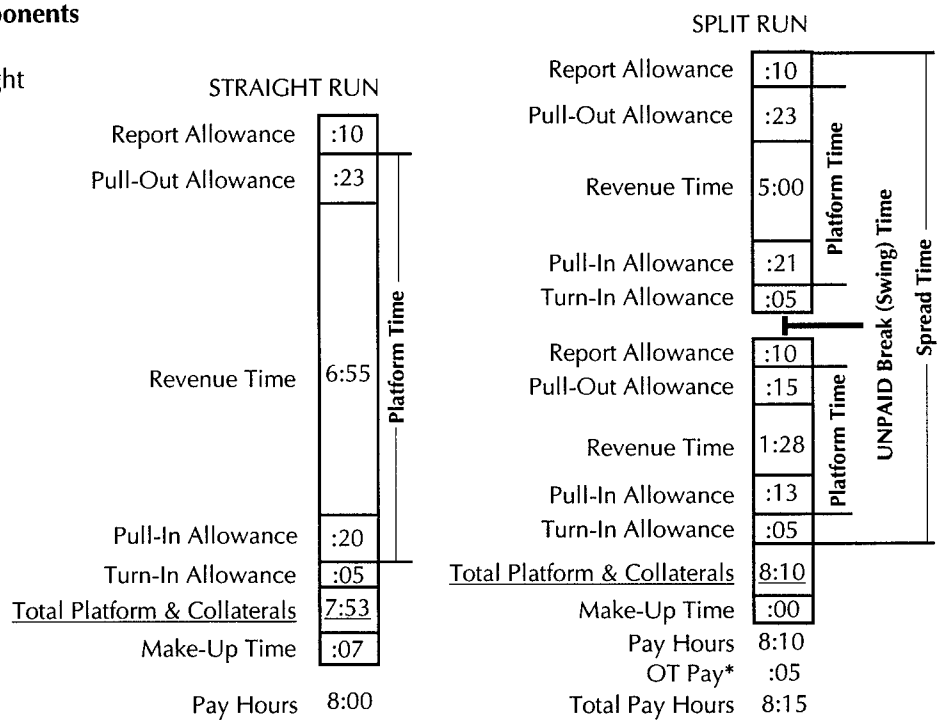
Make-up time

Make-up time is payment for time not actually worked by an operator in order that the total paid time for a run is equal to a minimum daily or weekly guarantee. For example, a run that totals 7:50 including all platform and report and turn-in allowances will be granted ten minutes of make-up time so that the total pay equals eight hours for the day.

Work Rule	For Route 32, a minimum of 8 hours daily pay is guaranteed.

Visualization of run components

The diagrams on the right illustrate the typical components of straight and split runs.



* Overtime pay at this agency is half time of all minutes in excess of 8 hours daily.

Review key points by answering these questions.

1) Match the following:

Runs	Vehicle Assignments
Blocks	Operator (driver) Assignments

2) Which of the following implies continuous work of longer duration... straight runs / split runs.

3) The break between split runs is paid / unpaid. This break is often called a s_ _ _ _ .

4) Runcutting defines the number of operators ultimately needed to operate the service reflected in the Master Schedule for a route. True or False

5) _ _ _ _ _ _ _ _ time is the total time during which an operator is scheduled to be behind the wheel of a revenue vehicle. As a work rule, this is defined in minimum/maximum terms for runs.

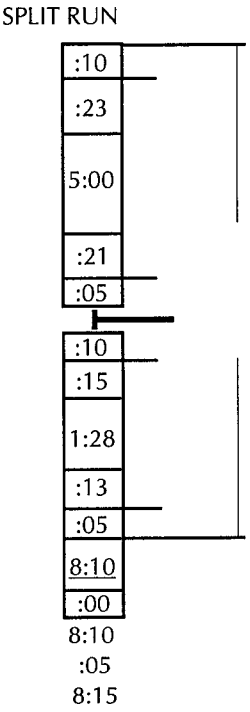
6) Match the following:

Report Allowance	Time paid an operator for duties prior to pull-out
Turn-In Allowance	Time paid an operator after pull-in

7) _ _ _ _ _ _ time is defined as the total elapsed time between the first report time and the final turn-in time of a run.

8) What is make-up time?

9) Identify each segment of the run visualization diagram on the right..



Summary of Route 32 Work Rules

Work Rule	Stipulation
Minimum Platform Time	Six (6) hours
Maximum Platform Time	Nine and one-half (9.5) hours
Report Allowance	Ten (10) minutes per pull-out
Turn-In Allowance	Five (5) minutes per turn-in
Spread Time	Thirteen (13) hours
Spread Penalty	1/2 of the minutes over 11:30 @ straight time
Run Type Percentages	Straights Minimum of one (1) from all base vehicles in revenue service at 11:00 a.m. Splits 1/3 within 12:00 spread, 1/3 within 12:30 spread, and no more than 1/3 within 13:00 spread
Make-Up Time	Up to eight (8) daily pay hours
Overtime	1/2 of the minutes over 8:00 hours daily

Estimating the number of runs

Step 1 in the runcutting process is the estimation of the number of runs to be cut from the blocks.

An estimate of the number of runs to be cut will enable the scheduler to assess, at various points in the process, if the progression is on target.

Too few or too many runs may indicate a missing block or a block that has been assigned twice. As the number of blocks in the pool increases, the importance of the estimate and periodic checks against it becomes more important.

A common estimation technique consists of dividing the total platform time contained in the blocks by a target number of platform hours to be included in each run.

For Route 32, the expectation is to cut runs from the block pool that contains approximately nine (9) platform hours each.

$$\frac{\text{Total Platform Hours}}{\text{Target Platform Hours Per Run}} = \text{Estimated Number of Runs}$$

Estimation equation for number of runs to be cut from a block pool.

Applying the above estimation equation to Route 32 yields the following results:

$$\frac{\text{26:38 (from Block Summary Recap in Chapter 3)}}{\text{9}} = 2.95 \text{ or } \mathbf{3}$$

The estimated number of runs for Route 32 is **3**.

Chronological block listing

Step 2 in the runcut process is often the listing of all of the blocks in such a way that the scheduler can more easily see that runs are being cut in a manner that conforms to existing work rules. One method involves listing

all A.M. blocks that pull-out prior to 11:59 a.m. in ascending (earliest to latest) pull-**OUT** order, and

all P.M. blocks that pull-out after 12:00 noon in ascending pull-**IN** order.

Listing the blocks in this order also helps facilitate the development of split runs that will conform to spread time limitations.

> In large block pools, a second sort order can be made according to ascending or descending platform time of blocks with the same pull-out or pull-in time. This secondary sort will facilitate the development of runs according to the platform requirement.

The chronological block listing format shown below is considered a typical listing "convention."

CHRONOLOGICAL BLOCK LISTING (FORMAT)

A.M. BLOCKS		P.M. BLOCKS	
Block Number	Platform Time	Block Number	Platform Time
Pull-Out Time (Earliest to Latest)	Pull-In Time	Pull-Out Time	Pull-In Time (Earliest to Latest)

Completing the chronological block listing for Route 32 yields the following table:

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

A.M. BLOCKS			P.M. BLOCKS	
	3201 6:00 a.m.	4:42 10:42 a.m.	3206 1:46 p.m.	3:56 5:42 p.m.
	3203 6:16 a.m.	3:56 10:12 a.m.	3205 1:30 p.m.	4:42 6:12 p.m.
	3202 6:30 a.m.	3:56 10:26 a.m.	3204 1:16 p.m.	5:26 6:42 p.m.
	Total A.M. Platform	12:34	Total P.M. Platform	14:04

Observations

With all of the blocks now listed in the chronological block listing, a number of observations can be made.

- There are no base (all day) blocks on Route 32.
- The lack of base blocks and the duration of the swing period (the time between the end of A.M. service and the beginning of P.M. service -- 10:42 a.m. to 1:16 p.m.) indicates that there will be no straight runs on Route 32.
- There is an equal number of A.M. and P.M. blocks - called piece balance. Piece balance is critical in assembling all block pieces into runs with no block pieces left over.
- Assuming that all of the block pieces can be coupled into legal runs, three split runs can be developed and there will be no pieces left over.

The possibilities for combining run pieces for Route 32 are limited. It is important to keep in mind that when multiple routes are involved, it is preferable to mix and match the pieces from the various routes in the most cost-effective runs possible.

Some agencies or labor agreements stipulate that each route has to be cut individually and the mixing of routes in the runs is disallowed.

This restrictive stipulation generally results in a more costly solution than could be obtained if all of the routes were pooled for the runcut (system runcut).

Optimization and the Run Guide

Optimization

In this stage of the runcutting process, the blocks that have been listed on the Chronological Block Listing are arranged into runs on a form referred to as the Run Guide. The Run Guide records the work and pay components of the various runs. The run information is recorded in such a way as to facilitate the scheduler's review of individual runs and the runs collectively.

This review helps the scheduler to determine if the most efficient matching of blocks is occurring. Reviewing and adjusting is known as "optimization." During optimization, the scheduler strives to

- achieve the fewest number of runs necessary to provide the desired level of service,
- equalize platform time and pay hours among the runs,
- ensure that runs conform to labor agreements and agency policies, and
- facilitate the calculation of accurate pay hours.

The greater the number of block pieces that exist, the greater the number of possibilities for creating and optimizing the runs.

The Run Guide

A representative Run Guide is shown below.

RUN GUIDE (example format)

RUN GUIDE

Service Days Effective:

Run No.	1st Piece Block	Route	Time On	Pull Out	Pull In	Time Off	2nd Piece Block	Route	Time On	Pull Out	Pull In	Time Off	Plat-form	Total Spread	Allowance Report	Turn In	Relief	Make Up	Work Hours	Over Time	Spread Penalty	Pay Hours
TOTALS													Plat-form		Allowance Report	Turn In	Relief	Make Up	Work Hours	Over Time	Spread Penalty	Pay Hours

In addition to the information on individual runs, the Run Guide also contains spaces to total all of the various run work and pay hour components. The information contained in the Run Guide can also help operators when they are given regular opportunities to pick (or bid) the runs that they choose to work. The order of the bid for available runs by operators is usually based on seniority.

The Run Guide can also provide valuable information for agency payroll/accounting systems.

Review key points by answering these questions.

1) An estimation of the number of runs to be cut will enable the scheduler to assess, at various points in the process, if the progression is on target. True or False

2) Complete the equation below.

$$\frac{\text{Total Platform Hours}}{\text{Target Platform Hours Per Run}} = \text{Number of } \_\_\_\_\_$$

3) In the Chronological Block Listing, A.M. blocks that pull-out prior to 11:59 a.m. are listed in ascending pull ___ order. All P.M. blocks that pull-out after 12:00 noon are listed in ascending pull ___ order.

4) Fill in the blank spaces in the chronological block listing format below.

A.M. BLOCKS		P.M. BLOCKS	
Block Number	Platform Time	Block Number	Platform Time
Pull-Out Time			
Earliest to Latest			Earliest to Latest

5) Piece _____ means that there are an equal number of A.M. and P.M. blocks.

6) A system runcut means that all routes are pooled for the runcut. True or False

7) During _____ the scheduler strives to achieve the fewest number of runs necessary to provide the desired level of service and equalize platform time and pay hours among the runs.

8) The greater the number of block pieces that exist, the greater the number of possibilities for creating and optimizing the runs. True or False

9) The Run Guide can provide valuable information for agency payroll/accounting systems. True or False

III. Cutting the Runs

The following eight steps are taken in the process of cutting the runs and completing the Run Guide.

1) The required heading information is filled in, consisting of the days of operation and the effective date of the runs.

2) After referring to the Chronological Block Listing, the earliest (first) A.M. piece is selected and recorded as the first piece of Run No. 1. Run Guides are generally developed on the basis of ascending report times within each run type. The Run Guide entry consists of the appropriate run number, block number, route number, pull-out and pull-in times.

Note: As determined earlier, there are no straight runs possible on Route 32. Many agencies list A.M. straight runs first on the Run Guide followed by midday and P.M. straights and finally the split runs.

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

A.M. BLOCKS			P.M. BLOCKS	
3201 6:00 a.m.	4:42 10:42 a.m.		3206 1:46 p.m.	3:56 5:42 p.m.
3203 6:16 a.m.	3:56 10:12 a.m.		3205 1:30 p.m.	4:42 6:12 p.m.
3202 6:30 a.m.	3:56 10:26 a.m.		3204 1:16 p.m.	5:26 6:42 p.m.
Total A.M. Platform	12:34		Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS Effective: 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32		600a	1042a																	

TOTALS	Platform	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

Note: It is good practice to develop a system of checks each time a block piece is transferred to the Run Guide. The Chronological Block Listing contains columns for checking off the block pieces each time one is transferred. An "X" is placed next to A.M. block 3201 to indicate that it has been used.

3) Referring to the Chronological Block Listing, a P.M. piece is selected that fits best with A.M. block 3201. It is important to keep in mind any spread time stipulations and maximum platform constraints. Generally, it is good policy to initially select the first P.M. piece that best meets the spread time stipulations. Since the P.M. pieces have been listed in pull-in order, block 3206 is the earliest pull-in and is selected as the second piece for Run No. 1. A quick check is made to be sure that the platform rule has not been violated.

The same information is recorded for block 3206 as was done for 3201. Additionally, the combined platform time of both pieces is recorded in the Platform column. Block 3206 is now shown as having been assigned a run.

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

A.M. BLOCKS			P.M. BLOCKS		
X	3201 6:00 a.m.	4:42 10:42 a.m.	X	3206 1:46 p.m.	3:56 5:42 p.m.
	3203 6:16 a.m.	3:56 10:12 a.m.		3205 1:30 p.m.	4:42 6:12 p.m.
	3202 6:30 a.m.	3:56 10:26 a.m.		3204 1:16 p.m.	5:26 6:42 p.m.
	Total A.M. Platform	12:34		Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS Effective: 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance	Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32		600a	1042a		3206	32		146p	542p		8:38										

TOTALS

Platform	Allowance	Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

Cutting the runs (con't)

4) The same process is then followed for the remaining Route 32 blocks.

COMPLETE THE RUNCUT INFORMATION FOR THE REMAINING 2 BLOCKS OF ROUTE 32
(answers are on the next page)

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

	A.M. BLOCKS			P.M. BLOCKS	
X	3201 6:00 a.m.	4:42 10:42 a.m.	X	3206 1:46 p.m.	3:56 5:42 p.m.
	3203 6:16 a.m.	3:56 10:12 a.m.		3205 1:30 p.m.	4:42 6:12 p.m.
	3202 6:30 a.m.	3:56 10:26 a.m.		3204 1:16 p.m.	5:26 6:42 p.m.
	Total A.M. Platform	12:34		Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days: **WEEKDAYS** **Effective:** **10/27/XX**

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32		600a	1042a		3206	32		146p	542p		8:38									
2																						
3																						
TOTALS													**Platform**		**Allowance Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**

Completing the runcuts (answers to the exercise on the previous page)

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

A.M. BLOCKS			P.M. BLOCKS		
X	3201 6:00 a.m.	4:42 10:42 a.m.	X	3206 1:46 p.m.	3:56 5:42 p.m.
X	3203 6:16 a.m.	3:56 10:12 a.m.	X	3205 1:30 p.m.	4:42 6:12 p.m.
X	3202 6:30 a.m.	3:56 10:26 a.m.	X	3204 1:16 p.m.	5:26 6:42 p.m.
	Total A.M. Platform	12:34		Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days: **WEEKDAYS** **Effective:** **10/27/XX**

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32		600a	1042a		3206	32		146p	542p		8:38									
2	3203	32		616a	1012a		3205	32		130p	612p		8:38									
3	3202	32		630a	1026a		3204	32		116p	642p		9:22									
TOTALS													**Platform**		**Allowance Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**

A review of the runs at this stage reveals that all of the runs are legal in terms of total platform time. Each run falls between the six (6) hour minimum and the nine and one-half (9 1/2) hour maximum.

5) The next step is to ascertain that the spread time is not going to exceed the maximum allowed and that the percentages allowed at each spread time interval is not exceeded.

Spread time and percentage recalled from the Work Rule Table:
Spread time limit: 13 hours
Spread percentages: 1/3 of all split runs must be within 12 hour spread, 1/3 must be within 12.5 hour spread and no more than 1/3 must fall within 13 hours spread.

Since Route 32 has produced 3 runs, no more than 1 can fall into the 12.5 spread level and no more than 1 can fall in the 13 hour spread level.

Reminder: Spread time is the total elapsed time between the first report time (time on) and the last turn-in time (time off).

Time on and time off allowances

Spread time does include time on and time off allowances. The report allowance (paid time prior to pull-out) has been established for Route 32 as 10 minutes. The time off allowance (from pull-in to the end of operator duties) for Route 32 has been established as 5 minutes.

These times are transferred to the Run Guide. The spread times are then determined.

RUN GUIDE - Route 32

RUN GUIDE

Service Days: **WEEKDAYS** **Effective:** **10/27/XX**

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32	550a	~~600a~~	~~1042p~~	~~1047a~~	~~3206~~	~~32~~	~~136p~~	~~146p~~	~~542p~~	547p	~~8:38~~	11:57								
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11								
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27								

TOTALS	Platform	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

All three runs are within the allowable spread time limit of 13 hours. In fact, none of the runs have fallen into the longest interval between 12:31 and 13:00 hours. One of the goals of the scheduler is to strive for the least amount of spread time, primarily for two reasons.

1) When a spread penalty exists (for exceeding spread limits), the least amount of spread translates into lower labor costs.

2) Operators tend to appreciate runs with the lowest possible spread time.

All three runs are legal in terms of both platform and spread times.

6) The next step is to complete the costing of the runs as follows:

   a) Total all of the report and turn-in allowances and record them under their respective columns. Note that split runs have <u>two</u> (10 min. each) report and <u>two</u> (5 min. each) turn-in allowances.

   b) Leave the relief column blank because there are no relief allowances for Route 32.

   c) Since all runs are in excess of eight (8) hours platform time, no make-up time is necessary.

   d) The Platform and Allowances columns are totalled and the sum is recorded in the Work Hours column.

RUN GUIDE - Route 32

RUN GUIDE

Service Days: **WEEKDAYS** **Effective:** **10/27/XX**

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1042p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08			
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08			
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52			

TOTALS	Platform	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

7) The next columns are the overtime and spread penalty columns. For overtime, "time and a half" is paid for all daily work hours over 8:00. For spread penalty, one-half of all minutes in excess of 11:30 is paid as straight time. Since only one-half of the excess minutes are recorded in these columns, the total pay hours calculated is total straight time.

   Overtime is any time over 8 hours per day.
   Overtime minutes column = (Work hours: 8:00) / 2

   Spread penalty is paid for any spread time over 11:30.
   Spread penalty minutes column = (Total Spread: 11:30) / 2

   Again, dividing these additional minutes in half and recording the resulting time in the Run Guide columns for overtime and spread penalty allows simple addition of the work hours with these times to compute the total Pay Hours, which is then paid at the straight rate.

Applying the equations for overtime to Run Nos. 1, 2 and 3 yields the following results:

Run	Work Hours	Limit	Excess	Excess (mins)	1/2 of min.=O/T Minutes
1	9:08	8:00	1:08	68	:34
2	9:08	8:00	1:08	68	:34
3	9:52	8:00	1:52	112	:56

Applying the equations for spread penalty works much the same way.

Run	Total Spread	Limit	Excess	Excess(mins)	1/2 of min.=Spread Penalty
1	11:57	11:30	:27	27	:14
2	12:11	11:30	:41	41	:21
3	12:27	11:30	:57	57	:29

The Run Guide is now updated to include these amounts.

RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS **Effective:** 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1042p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08	:34	:14	
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08	:34	:21	
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52	:56	:29	

TOTALS	Platform	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

8) The final step in completing the runcutting process for Route 32 is to total the various columns on the Run Guide and cross check the totals to verify the accuracy of the computations.

RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS **Effective:** 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1042p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08	:34	:14	9:56
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08	:34	:21	10:03
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52	:56	:29	11:17

	Platform	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
TOTALS	26:38	1:00	:30	0	0	28:08	2:04	1:04	31:16

Verification:

Total Pay Hours for Route 32 runs are 31:16. This total was determined and verified by adding both the Pay Hour Column vertically and the total Platform, Report Allowance, and Turn-in Allowance (Work Hours) with the Overtime and Spread Penalty to get the total Pay Hours horizontally.

Review key points by answering these questions.

Given the following information, complete the Run Guide below.

Summary of Route 32 Work Rules

Work Rule	Stipulation
Minimum Platform Time	Five (5) hours
Maximum Platform Time	Ten (10) hours
Report Allowance	Ten (10) minutes per pull-out
Turn-in Allowance	Five (5) minutes per turn-in
Spread Time	Thirteen (13) hours
Spread Penalty	1/2 of the minutes over 12:00 @ straight time
Run Type Percentages	Straights: Minimum of one (1) from all base vehicles in revenue service at 8:00 a.m.
	Splits: 1/2 within 11:00 spread, 1/2 within 12:00
Make-up Time	Up to eight (8) daily pay hours
Overtime	1/2 of the minutes over 8:00 hours daily

CHRONOLOGICAL BLOCK LISTING - ROUTE 32

A.M. BLOCKS		P.M. BLOCKS	
3201 6:00 a.m.	4:42 10:42 a.m.	3206 1:46 p.m.	3:56 5:42 p.m.
3203 6:16 a.m.	3:56 10:12 a.m.	3205 1:30 p.m.	4:42 6:12 p.m.
3202 6:30 a.m.	3:56 10:26 a.m.	3204 1:16 p.m.	5:26 6:42 p.m.
Total A.M. Platform	12:34	Total P.M. Platform	14:04

RUN GUIDE - Route 32

RUN GUIDE

Service Days:

Effective:

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
TOTALS													Plat-form		Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours

Notes:

CHAPTER 5

ROSTERING

Operators Required and Days Off for 8 Hour Runs:

Day	Number of Daily Runs	X	Weekly Total
Weekdays ([M - F]	120	5	600
Saturdays	54	1	54
Sundays	26	1	26
Weekly Total			680
Total Operators [Weekly total divided by 5 days of work per operator]			136

Master Lists

Weekday Runs Run	Platform time	Sat Runs Run	Platform time	Sun Runs Run	Platform time
01	8:00	51	8:15	61	9:10
02	8:00	52	8:21	62	9:05
03	8:12	53	8:00		
04	8:51				

Available Days Off

Su	Mo	Tu	We	Th	Fr	Sa
3	1	1	1	1	1	2

Weekday Master RUN GUIDE - Route 32

RUN GUIDE

Service Days: WEEKDAYS — Effective: 10/27/XX

Run No.	1st Piece Block	Route	Time On	Pull Out	Pull In	Time Off	2nd Piece Block	Route	Time On	Pull Out	Pull In	Time Off	Platform	Total Spread	Allowance Report	Turn In	Relief	Make Up	Work Hours	Over Time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1043p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08	:24	:14	9:56
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08	:24	:21	10:03
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52	:56	:29	11:17

No Saturday Runs

No Sunday Runs

Master Day Off List

Sun	Mon	Tues	Wed	Thur	Fri	Sat
3	0	0	0	0	0	3

Day	Roster With daily guarantee			Roster Without daily guarantee		
	Work	Guarantee	Pay	Work	Guarantee	Pay
Sunday	OFF			OFF		
Monday	OFF			OFF		
Tuesday	7:50	:00	8:00	7:50	:00	7:50
Wednesday	7:50	:00	8:00	7:50	:00	7:50
Thursday	7:50	:00	8:00	7:50	:00	7:50
Friday	7:50	:00	8:00	7:50	:00	7:50
Saturday	8:40	:00	8:40	8:40	:00	8:40
TOTAL	40:00	:00	40:40*	40:00	:00	40:00

* 40 minutes of overtime paid for the workweek.

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	OFF	1 / 9:56	1 / 9:56	1 / 9:56	1 / 9:56	OFF	
102	OFF	2 / 10:03	OFF	2 / 10:03	2 / 10:03	2 / 10:03	OFF	
103	OFF	3 / 11:17	3 / 11:17	3 / 11:17	3 / 11:17	OFF	OFF	
104	OFF	1 / 9:56	2 / 10:03	OFF	OFF	3 / 11:17	OFF	

Study Objectives

1) Learn that rostering is the process of grouping daily operator runs into weekly run packages.
2) Remember that weekly rosters combine runs and days off into weekly operator assignments.
3) Understand the basic difference between operator developed (cafeteria style) rostering and agency developed rostering.
4) Be able to recognize and understand typical constraints for rostering under the cafeteria approach.
5) Be able to cite cost saving potential in each type of rostering approach.
6) Name an advantage of using the cafeteria style rostering approach.
7) Be prepared to explain the process for preparing variations for a particular agency developed roster.
8) Name an advantage of using the agency developed rostering approach.
9) Remember what type of charts are frequently used to present quantifiable information to aid in the evaluation of the rostering variations.
10) Learn the definition of equivalent straight time hours.

I. Introduction

What is "rostering"?

Rostering is the process of "grouping" daily operator runs into weekly run packages.

Operators are generally given the opportunity, based on order of seniority, to "pick" (choose) the run packages they will work for the next interval of time (often called bid period or mark-up period). At most agencies, mark-ups generally occur 3 or 4 times a year.

These weekly rosters may include mixtures of runs, such as

- weekday runs only,
- weekday runs and a Saturday run,
- weekday runs and a Sunday run,
- weekday runs and a Saturday run and a Sunday run.

Weekly run packages or rosters usually consist of five daily 8-hour runs. However, at agencies where 10-hour daily runs exist, the weekly rosters may consist of four daily runs. Where part-time operators are utilized, the weekly rosters may consist of two, three or four daily runs.

Some agencies even develop rosters with five 10-hour daily runs as a method of reducing the number of required operators. However, as expected, this rostering practice results in a high level of weekly overtime.

Rosters will generally remain in effect until the next mark-up.

Weekly Roster No.	Su	Mo	Tu	We	Th	Fr	Sa	Weekly Pay Hours
101	Off	1/8:00	1/8:00	1/8:00	1/8:00	1/8:00	Off	40:00
102	Off	2/8:00	2/8:00	2/8:00	2/8:00	Off	51/8:00	40:00
103	62/10:00	3/10:00	3/10:00	3/10:00	Off	Off	Off	40:00
104	Off	Off	4/10:00	4/10:00	4/10:00	4/10:00	Off	40:00
105	61/8:00	4/8:00	4/8:00	4/8:00	4/8:00	Off	Off	40:00

Example of a weekly roster

II. Types of Rostering

Rostering, depending on work rules and agency policy, is performed in one of two ways

- Operator developed (cafeteria style) or
- Agency developed.

Operator developed (cafeteria style) rostering

Under the operator developed or cafeteria style of rostering, an operator can choose both specific daily runs **and** days off from a master list or lists, just as a customer in a cafeteria line can choose individual food items that make up a complete food tray.

When it is time to mark-up, the Schedule and/or Operations department(s) posts master lists containing all weekday, Saturday and Sunday runs, and available days off. The master lists may be the actual Run Guides for each day or some variation of the Run Guide.

In the example master list(s) shown below, the two digit numbers that begin with "0" indicate that the runs are weekday (M - F) runs. The two digit numbers that begin with "5" indicate that these runs are Saturday runs. Those runs that begin with "6" are Sunday runs.

The available days off list displays the total number of days off that may be chosen for each day of the week.

Master Lists

Weekday Runs			Sat Runs			Sun Runs		
Run		Platform time	Run		Platform time	Run		Platform time
01	-	8:00	51	-	8:15	61	-	9:10
02	-	8:00	52	-	8:21	62	-	9:05
03	-	8:12	53	-	8:00			
04	-	8:51						

Available Days Off

Su	Mo	Tu	We	Th	Fr	Sa
3	1	1	1	1	1	2

Operator developed rostering allows operators to combine runs and days off according to work rules.

In addition, a master list of available extra board (relief, standby, etc.) is posted along with a master list of eligible operators. The operator list generally displays operators in seniority order with the day and time of their turns to pick listed next to their names. Picking runs and days off can be as simple as initialling the runs and days off on the master lists.

Schedule and/or Operations department personnel and if applicable, union personnel, generally "officiate" during the mark-up to ensure that operators pick work according to the seniority list and that all rules governing the cafeteria roster and mark-up process are adhered to.

Variants of the cafeteria approach

There are a number of variants under the cafeteria approach, ranging from no restrictions to many restrictions. Typical constraints for rostering under the cafeteria approach include

- Days off must be consecutive as long as the opportunity to select them exists.
- Routes cannot be mixed during the work week until such time as the same route is not available for all work days of the week.
- Run types (straight/split) cannot be mixed until necessary to form full weekly rosters.
- A certain number of off duty hours (usually 8) must exist between each daily run.

Cafeteria rostering is generally addressed very specifically in a labor agreement.

Agency developed rostering

Under the agency developed rostering approach, the weekly runs and days off are chosen by the agency and combined into the weekly rosters (see 101 - 105 below). Operators then pick from the list of weekly rosters.

The major difference from the operator developed (cafeteria) approach is that with the agency developed approach, the transit system combines the daily runs and days off before posting. Using the comparison to the cafeteria line, this means that operators choose from a selection of prepackaged complete food trays rather than picking the individual food items that make up the food tray.

Each operator, generally based on seniority, picks a weekly roster from the agency developed roster package. These are the runs the operator will work until the next mark-up period.

Weekly Roster No.	Su	Mo	Tu	We	Th	Fr	Sa	Weekly Pay Hours
101	Off	1/8:00	1/8:00	1/8:00	1/8:00	1/8:00	Off	40:00
102	Off	2/8:00	2/8:00	2/8:00	2/8:00	Off	51/8:00	40:00
103	62/10:00	3/10:00	3/10:00	3/10:00	Off	Off	Off	40:00
104	Off	Off	4/10:00	4/10:00	4/10:00	4/10:00	Off	40:00
105	61/8:00	4/8:00	4/8:00	4/8:00	4/8:00	Off	Off	40:00

Agency developed rosters contain a combination of both runs and days off. Operators choose from weekly roster numbers.

Potential cost savings associated with each approach

Operator developed (cafeteria) rostering - cost awareness

In support of the operator developed (cafeteria) approach, many transit systems believe that operators are more conscientious about the quality of their work when they have additional control over their work hours and assignments.

In theory, that increased operator conscientiousness could translate into potential costs savings associated with improved attendance, fewer accidents, reduced worker compensation claims, and fewer customer complaints.

Agency developed rostering - cost awareness

Many transit systems prefer the agency developed approach because in many cases the pre-assembled rosters can be developed in a more cost-effective manner.

This is especially true for agencies where a daily guarantee does not have to be paid. In those cases, the agency can combine large daily runs (over 8 hours) with small daily runs (under 8 hours) into weekly rosters of 40 pay hours or fewer. Overtime pay (when paid for time worked over 40 hours in a week) is thus minimized or avoided altogether. (See example below.)

As with runcutting, the more daily runs there are to work with, the greater the opportunity for enhanced cost-effectiveness in developing the weekly rosters.

The example below demonstrates the potential cost savings for a transit system using the agency developed rostering approach when daily guarantees are not paid. In this case, one large run (over 8 hours) can be combined with 4 other daily runs to equal 40 weekly pay hours. No overtime pay is necessary because the operator does not work over 40 hours per week.

Day	Roster with daily guarantee			Roster without daily guarantee		
	Work	**Guarantee**	**Pay**	**Work**	**Guarantee**	**Pay**
Sunday	OFF			OFF		
Monday	OFF			OFF		
Tuesday	7:50	:10	8:00	7:50	:00	7:50
Wednesday	7:50	:10	8:00	7:50	:00	7:50
Thursday	7:50	:10	8:00	7:50	:00	7:50
Friday	7:50	:10	8:00	7:50	:00	7:50
Saturday	8:40		8:40	8:40	:00	8:40
TOTAL	40:00	**:40**	**40:40***	40:00	:00	40:00

* 40 minutes of overtime paid for the work week.

Agency developed rosters provide an opportunity to combine daily runs of over 8 hours with daily runs of under 8 hours so as not to exceed 40 pay hours per week.
This applies only where daily guarantees are not paid.

Of note:

It is important to note that, in the absence of daily guarantees and overtime, savings are also possible under the cafeteria approach. However, those savings are typically random and generally do not reach the potential savings associated with the agency developed rostering approach.

Often, under the cafeteria approach, more senior operators develop their weekly roster to include daily runs with over 8 hours in order to qualify for weekly overtime pay. Since senior operators usually pick first during the mark-ups, more junior operators are often left with runs that pay 8 hours or fewer per work day. As a result, some operators are paid high levels of weekly overtime while less senior operators are left with rosters that pay 40 hours or fewer.

Review key points by answering these questions.

1) Rostering is the process of grouping _ _ _ _ _ operator runs into _ _ _ _ _ _ run packages.

2) Weekly run packages or rosters usually consist of five daily 8 hour runs. True or False

3) Rosters will generally remain in effect until the next _ _ _ _ - _ _.

4) Rostering, depending on work rules and agency policy, is performed in one of two ways...

   1. (list type)

   2. (list type)

5) Under the _ _ _ _ _ _ _ _ developed (cafeteria) style of rostering, an operator can choose both days off and specific daily runs from a master list or lists.

6) During mark-up, operators generally pick work based on their order of seniority. True or False

7) Which of the following is (are) typical of the constraints applicable to cafeteria rostering?

   - days off must be consecutive as long as the opportunity to select them exists
   - run types (straight/split) cannot be mixed until necessary to form full weekly rosters
   - a certain number of hours (usually 8) must exist between each daily run
   - all of the above
   - none of the above

8) The diagram on the right is an example of an agency developed roster. True or False

Weekly Roster No.	Su	Mo	Tu	We	Th	Fr	Sa	Weekly Pay Hours
101	Off	1/8:00	1/8:00	1/8:00	1/8:00	1/8:00	Off	40:00
102	Off	2/8:00	2/8:00	2/8:00	2/8:00	Off	51/8:00	40:00
103	62/10:00	3/10:00	3/10:00	3/10:00	Off	Off	Off	40:00
104	Off	Off	4/10:00	4/10:00	4/10:00	4/10:00	Off	40:00
105	61/8:00	4/8:00	4/8:00	4/8:00	4/8:00	Off	Off	40:00

9) The diagram on the right is an example of part of the process of developing a cafeteria roster. True or False

Master Lists

Weekday Runs Run	Platform time	Sat Runs Run	Platform time	Sun Runs Run	Platform time
01	8:00	51	8:15	61	9:10
02	8:00	52	8:21	62	9:05
03	8:12	53	8:00		
04	8:51				

Available Days Off

Su	Mo	Tu	We	Th	Fr	Sa
3	1	1	1	1	1	2

10) Name one potential advantage (cost or otherwise) of the cafeteria rostering approach.

11) Name one potential advantage (cost or otherwise) of the agency developed rostering approach.

12) Under which approach are more senior operators more likely to include more daily runs which pay over 8 hours in order to qualify for weekly overtime pay?

Example: CAFETERIA Rostering Approach

Under the cafeteria rostering approach, operators pick their weekly roster work from the master days off and daily run lists. These master lists are either the actual Run Guide(s) or derived directly from the Run Guide(s).

For Route 32, the master day off and daily run lists originate with the Run Guide developed in Chapter 4.

The master days off and daily runs for this simple example are shown below

Weekday Master RUN GUIDE - Route 32

RUN GUIDE

Service Days: **WEEKDAYS** **Effective:** **10/27/XX**

Run No.	1st Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	2nd Piece Block	Route	Time On	Pull-out	Pull-in	Time Off	Platform	Total Spread	Allowance Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
1	3201	32	550a	600a	1042p	1047a	3206	32	136p	146p	542p	547p	8:38	11:57	:20	:10			9:08	:34	:14	9:56
2	3203	32	606a	616a	1012a	1017a	3205	32	120p	130p	612p	617p	8:38	12:11	:20	:10			9:08	:34	:21	10:03
3	3202	32	620a	630a	1026a	1031a	3204	32	106p	116p	642p	647p	9:22	12:27	:20	:10			9:52	:56	:29	11:17

No Saturday Runs

No Sunday Runs

Master Day Off List

Sun	Mon	Tues	Wed	Thur	Fri	Sat
3	0	0	0	0	0	3

Because Route 32 operates only on weekdays, available off days are on Saturdays and Sundays only.

The number of available days off is equal to the number of weekday runs that may be picked by operators. A formula for computing the number of available days off is demonstrated on the following pages.

Formula for computing days off and required operators

Operators Required and Days Off for 8-Hour Runs:

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]	120	5	600
Saturdays	54	1	54
Sundays	26	1	26
Weekly Total			680
Total Operators [Weekly total divided by 5 days of work per operator]			136

Day Off Distribution:

	Total Number of Operators	Minus Daily Runs	Operators off Each Day
Weekdays [M - F]	136	120	[M,T,W,T,F] 16
Saturdays	136	54	82
Sundays	136	26	110
Total [Weekday x 5 plus Saturday plus Sunday]			272

Check:

Total Off Days Required - [Total Operators x 2 days]	272
Total Off Days Assigned - [Sum of Operators Off Each Day]	272
Leftover Days	0

Operators Required and Days Off for 10-Hour Runs:

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]	100	5	500
Saturdays	40	1	40
Sundays	40	1	40
Weekly Total			580
Total Operators [Weekly total divided by 4 days of work per operator]			145

Day Off Distribution:

	Total Number of Operators	Minus Daily Runs	Operators off Each Day
Weekdays [M - F]	145	100	[M,T,W,T,F] 45
Saturdays	145	40	105
Sundays	145	40	105
Total [Weekday x 5 plus Saturday plus Sunday]			435

Check:

Total Off Days Required - [Total Operators x 3 days]	435
Total Off Days Assigned - [Sum of Operators Off Each Day]	435
Leftover Days	0

Using Route 32 data, complete the following Summary of Operators Required and Days Off Formula. (Note: Answers are show below.)

Operators Required and Days Off for 8-Hour Runs:

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]			
Saturdays			
Sundays			
Weekly Total			
Total Operators [Weekly total divided by 5 days of work per operator]			

Day Off Distribution:

	Total Operators	Minus Daily Runs	Operators off Each Day
Weekdays [M - F]			[M,T,W,T,F]
Saturdays			
Sundays			
Total [Weekday x 5 plus Saturday plus Sunday]			

Check:

Total Off Days Required - [Total Operators x 2 days]	
Total Off Days Assigned - [Sum of Operators Off Each Day]	
Leftover Days	

ANSWERS TO ABOVE

Operators Required and Days Off for 8-Hour Runs:

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]	3	5	15
Saturdays	0	1	0
Sundays	0	1	0
Weekly Total			15
Total Operators [Weekly total divided by 5 days of work per operator]			3

Day Off Distribution:

	Total Operators	Minus Daily Runs	Operators off Each Day
Weekdays [M - F]	3	3	[M,T,W,T,F] 0
Saturdays	3	0	3
Sundays	3	0	3
Total [Weekday x 5 plus Saturday plus Sunday]			6

Check:

Total Off Days Required - [Total Operators x 2 days]	6
Total Off Days Assigned - [Sum of Operators Off Each Day]	6
Leftover Days	0

Example: AGENCY DEVELOPED Rostering Approach

As explained earlier, under the agency developed rostering approach, operators pick their weekly roster work from a master list of weekly rosters. When developing those weekly rosters, it is very common for the agency to consider several variations before deciding on the final version to post.

As shown before, a common convention for the form used for posting weekly rosters is as follows:

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	# / X:XX	# / X:XX	# / X:XX	# / X:XX	# / X:XX	OFF	XX:XX

In the example form convention above, a 100 series number is assigned as the weekly roster number to help avoid confusion with the numbers used to represent the daily runs. "#" represents the daily run number under the days of the week columns and "X:XX" represents the pay hours associated with the run, both in the daily and in the weekly pay hours column.

For variation 1 below, the scheduler quickly assesses that all operators will be off on Saturdays and Sundays. Daily runs from Route 32 are simply transferred to the Roster below.

ROSTER - Route 32 (variation 1)

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	1 / 9:56	1 / 9:56	1 / 9:56	1 / 9:56	1 / 9:56	OFF	49:40
102	OFF	2 / 10:03	2 / 10:03	2 / 10:03	2 / 10:03	2 / 10:03	OFF	50:15
103	OFF	3 / 11:17	3 / 11:17	3 / 11:17	3 / 11:17	3 / 11:17	OFF	56:25

These are long and consistent runs. Generally, an agency is reluctant to develop weekly rosters that contain such high levels of overtime (time over 40 hours weekly) unless there is a compelling reason to keep the overall number of operators at a minimum.

One argument for longer runs and fewer operators is to reduce the cost of medical premiums, pension obligations, worker compensation exposure and other costs. However, these savings could potentially be offset by the increased costs of accidents and absenteeism that may be associated with working longer hours.

In the example of Route 32, because there are no other runs to work with, few choices exist for mitigating the high levels of weekly overtime. Variation 2 (presented on the next page) offers one alternative.

Example: AGENCY DEVELOPED Rostering Approach (con't)

Under variation 2, the option of creating 4 weekly run packages is explored. Obviously four operators, not three, would be needed to provide this service. The additional operator will add both direct and indirect costs that may or may not be offset by savings in overtime. Further evaluation is beneficial.

ROSTER - Route 32 (variation 2)

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	OFF	1 / 9:56	1 / 9:56	1 / 9:56	1 / 9:56	OFF	39:44
102	OFF	2 / 10:03	OFF	2 / 10:03	2 / 10:03	2 / 10:03	OFF	40:12
103	OFF	3 / 11:17	3 / 11:17	3 / 11:17	3 / 11:17	OFF	OFF	45:08
104	OFF	1 / 9:56	2 / 10:03	OFF	OFF	3 / 11:17	OFF	31:16

In variation 2 above, weekly roster no. 104 is made up of daily runs from weekly roster numbers 101, 102 and 103 (as they were developed in variation 1). Also, in variation 2, each roster 101 - 103 works 4 days per week instead of 5. The fifth daily run of each variation 1 weekly roster was assigned to 104 above.

However, many agencies believe that it is important for an operator not to switch daily runs too frequently during the week. These agencies believe that the operator's familiarity with the route configuration and regular passengers on that run is desirable. With this consideration, some additional cost may therefore be justified.

Where mixing and matching runs is not a critical consideration, a third variation for Route 32 could result in more evenly distributed work hours. Variation 3 (below) is an example of that approach.

ROSTER - Route 32 (variation 3)

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	OFF	1 / 9:56	1 / 9:56	2/ 10:03	2/ 10:03	OFF	
102	OFF	2 / 10:03	OFF	2 / 10:03	1/ 9:56	1/ 9:56	OFF	
103	OFF	1/ 9:56	2/ 10:03	3 / 11:17	3 / 11:17	OFF	OFF	
104	OFF	3 / 11:17	3 / 11:17	OFF	OFF	3 / 11:17	OFF	

Exercise: Compute the weekly pay hours for the weekly rosters in variation 3 above.

III. Evaluating the Agency Developed Roster Variations

Choosing between variations is often somewhat arbitrary. However, cost considerations are extremely important. Some leniency is often officially or unofficially factored in to accommodate the considerations mentioned earlier, such as operator run familiarity, consistency of runs worked and others.

Comparison charts are frequently used to present quantifiable information to aid in the evaluation of the variations. An example comparison chart for the three variations of agency developed rosters for Route 32 is shown below.

	Variation 1	Variation 2	Variation 3
Total pay hours for all weekly rosters	156:20	156:20	156:20
@ Straight time	120:00	151:00	153:47
@ Overtime	36:20	5:20	2:33
Equivalent straight time hours*	174:30	159:00	157:37
Number of operators required	3	4	4

Comparison charts are frequently used to help evaluate quantifiable information.

* Equivalent straight time hours is the sum total of overtime hours multiplied by 1.5 (because overtime is paid at time and a half) plus regular straight time hours.

Observations about the variations

Variation 1

Variation 1 results in the greatest overall cost in terms of equivalent straight hour pay. However it does require the fewest number of operators. Fewer operators could result in savings in training costs, medical premiums, pension contributions, worker compensation exposure and premiums, uniforms and other related personnel costs. Safety and absenteeism issues may exist since Variation 1 rosters are 5-day packages consisting of large daily runs.

Variation 2

Variation 2 is less costly than Variation 1 in terms of overall equivalent straight hours. However Variation 2 requires all the related hiring, training and maintenance costs (and fringe costs) associated with employing an additional operator.

Variation 3

Variation 3 is the least costly in terms of equivalent straight time hours. However Variation 3 still requires an additional operator that Variation 1 does not. Agency policy on direct cost, customer service and contingent costs plays an important role in the decisionmaking process.

Review key points by answering these questions.

1) Under the cafeteria rostering approach, operators pick their weekly roster work from the master days off and daily run lists. True or False

2) The following form convention is commonly used for posting weekly agency developed rosters. True or False

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	# / X:XX	# / X:XX	# / X:XX	# / X:XX	# / X:XX	OFF	XX:XX

3) Compute the weekly pay hours in the example below, then complete the column for variation X in the comparison chart shown below.

ROSTER - Route 32 (variation X)

Weekly Roster No.	Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Pay Hours
101	OFF	OFF	1 / 9:56	1 / 9:56	1 / 9:56	1 / 9:56	OFF	
102	OFF	2 / 10:03	OFF	2 / 10:03	2 / 10:03	2 / 10:03	OFF	
103	OFF	3 / 11:17	3 / 11:17	3 / 11:17	3 / 11:17	OFF	OFF	
104	OFF	1 / 9:56	2 / 10:03	OFF	OFF	3 / 11:17	OFF	

	Variation X
Total pay hours for all weekly rosters	
@ Straight time	
@ Overtime	
Equivalent straight time hours	
Number of operators required	

TRANSIT SCHEDULING: ADVANCED MANUAL

CONTENTS

CHAPTER 1

SERVICE POLICIES AND SCHEDULE DEVELOPMENT

Advanced Section

I. Introduction

Responsive schedule making is a dynamic process, evolving along with the ridership trends, service demands and funding opportunities of the community. As ridership patterns change, schedulers are often faced with the complex task of making adjustments to schedules while keeping costs as low as possible. Sound decisions necessarily require timely and accurate information. Historically, a number of methods have been utilized to provide this information, taking advantage of a wide variety of data collection and analysis techniques.

Many of the elements of scheduling and schedule adjustments can be performed with the assistance of commercially available automated scheduling software. Some systems have customized software for specific scheduling applications. Even general spreadsheet and database software can provide a valuable resource for schedulers, in particular, for keeping track of data, evaluating alternative approaches and producing scheduling forms. The "metaphors" or guiding theories behind scheduling software design, input to output, is typically consistent with the principles covered in the manual approach.

II. Types of Data

Using various kinds of transit operating data is a fundamental part of effective schedule making. Two types of data are particularly important for making efficient and effective schedules. They are as follows:

> **Passenger traffic data** provides information about ridership volumes and distribution necessary to support decisions about route design and service level issues. Primary passenger traffic information sources include boardings and alightings by vehicle stop, maximum load data collected at high volume points along each route and individual trip counts collected by bus operators, on-board checkers or on-board automatic passenger counters (APCs).
>
> **Vehicle running time data** provides information needed to determine route cycle time, create timed transfers and ensure schedule reliability. Primary running time information sources include scheduled running times, schedule adherence checks, automated vehicle location (AVL) system data, vehicle stop inventory information, and extended dwell time requirements (e.g., time allotted to board wheelchair users, provide for mid-route timed transfers to other routes, and so forth).

A. Passenger traffic data

Sources for passenger traffic data vary from system to system. Examples of typical passenger traffic data collected are 1) Boardings/Alightings by Stop, 2) Maximum Load Points and 3) Trip Counts.

1) Boardings/alightings by stop

Extremely useful to the schedule maker is knowing where and how many passengers board, alight or ride past particular stops or segments on a route. These data are generally collected with *ride checks*. Ride checks involve the systematic placement of people, called checkers, on revenue vehicles. Checkers record information on stop location, number of passengers boarding and alighting, number of passengers on the vehicle as it departs each stop and schedule adherence. Checkers often remain on a particular vehicle for an entire set of trips. Ride check information can be recorded manually or electronically.

Manual ride check information may be recorded on a form similar to the one shown below. The information on the form may then be entered into a computer spreadsheet or database program which allows the scheduler to summarize the data by direction, time period, route segment, individual trip or total route.

Checkers may also enter their data into small programmable calculators or palmtop computers. Other systems use APCs which consist of infrared or pressure sensors at the bus door(s). These sensors, used in conjunction with vehicle locator systems, automatically record boarding and alighting information which can be subsequently linked to location. Data are then downloaded into system computers for further analysis and report generation.

In either case, the ability to access and evaluate the data allows the scheduler much greater flexibility in maintaining system efficiency. For example, when ridership is low on a particular route, the scheduler may investigate the possibility of adjusting spacing between trips, adding or removing vehicles from the line and short-turning trips to adjust service to meet the demand over the length of the route.

RIDE CHECK FORM

Day: **Monday** Date: **10/12/xx** Weather: **Clear & Sunny, 72°**

Route: **32** Traffic: **Light**

Direction: **Westbound** Vehicle #: **8501**

Scheduled Trip Start Time: **6:26a** Scheduled Trip End Time: **7:04a**

Actual Trip Start Time: _____ Actual Trip End Time: _____

		Passengers			Time		
	Stop	On	Off	Lob*	Scheduled	Actual	Variance
1.	Comanche @ Big Sky	6	0	6	6:26a	6:27a	-1
2.	El Rio	2	0	8		6:27	
3.	Portola	5	0	13		6:27	
4.	Louisiana	2	0	15		6:28	
5.	Davis	3	0	18		6:29	
6.	Alta	1	1	18		6:31	
7.	Cordoba	4	0	22		6:32	
8.	Denali	6	0	28		6:34	
9.	Comanche @ Wyoming	2	12	18	6:35	6:35	0

* **Left on Board**

Example of a partially completed ride check data collection form

2) Maximum load points (MLPs)

Passenger loading, departing and left-on-board (LOB) data provides a relationship between passenger loads and location. The location(s) where the number of passengers is greatest is called the maximum load point (MLP).

Once the MLP for a route has been determined by a ride check, the ongoing verification of that stop (and the number of passengers on board at that stop) can be confirmed with a *point check* (also called load checks) taken at the MLP. Point checks differ from ride checks because the checker is stationary at the location and not a rider on the revenue vehicle.

Note: Point checks can be used to monitor service at any important or active location along a route. Often, point checks are conducted at locations where routes overlap or intersect. This way, one checker can record data for more than one route. The point check data are often recorded on a form similar to the one shown below.

POINT CHECK FORM

Day: **Monday** Road Surface: **Clear**

Date: **April 1, XXXX** Traffic: **Moderate**

Direction: **Westbound** Location: **4GR-4th @ Griegos**

Type: Arriving _____ Leaving _____

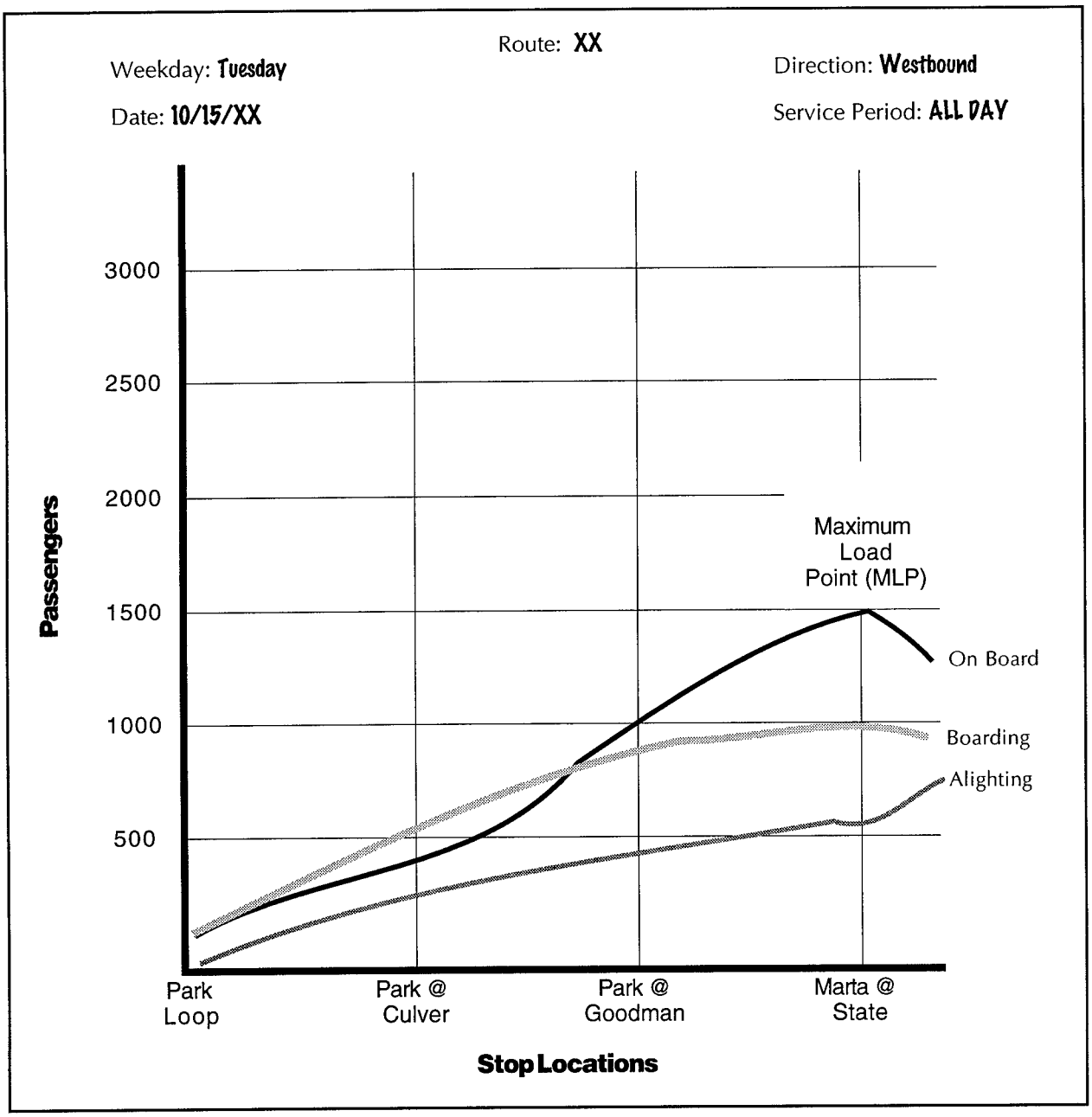
		Passengers	Time		
Route	Vehicle #	On Board	Scheduled	Actual	Variance
14	8005	38	6:15a	6:18a	-3
20	7656	51	6:30	6:32	-2
30	8063	25	6:40	6:44	-4
14	8021	44	6:45	6:45	0
32	8014	16	6:55	6:53	+2
20	7609	21	7:00	7:08	-8

Example of a point check form

In the example shown above, a negative variance is noted when a revenue vehicle passes the check location late (6:15a scheduled vs. 6:18a actual, recorded as -3). A positive variance is recorded when a revenue vehicle passes the check point early (6:55a vs. 6:53a, recorded as +2). Some systems will note the reverse, i.e., a positive variance when a vehicle passes late and a negative variance when a vehicle passes early.

Boarding/alighting data may also be arranged graphically into a **route profile diagram** (as shown on the next page). The route profile is a graph that shows the accumulated load (total number of passengers on board) at any point along the route on a single trip, multiple trips, a time period or all day. It may also display total boardings and alightings at each stop. The boardings and alightings data allow identification of individual stops with significant passenger activity.

The highest point on the graph represents the MLP. Some routes may have more than one MLP.



Example of a route profile diagram

3) Passenger trip counts

Passenger trip counts are the total passenger boardings on each one-way trip. Depending on how the information is collected, it may also show a distribution of passengers by fare type. It is the least specific form of passenger traffic data because it shows total boardings and not the distribution of passengers over the entire trip. It can, however, be a good indicator of possible overcrowding or underutilization of resources and is the simplest, most direct way to determine ridership growth trends on a particular route.

B. Vehicle running time data

1) Calculated running times

Calculated running times are used primarily when developing new routes or segments. In these cases, no actual running time history is usually available. Running times between nodes are developed in several steps, usually beginning with calculations based on average operating speed or data collected in an automobile check, which may be followed by simulated operation using an out-of-service vehicle or training vehicle. A "mileage wheel" may also be used to calculate distance. This hand-held device is run along a map of the route and factored with the map distance scale. Applying a speed factor yields route segment running time estimates.

2) Schedule adherence data

Schedule adherence data consists of comparisons between existing scheduled running times and actual running times measured through field checks. It is useful either to validate the accuracy of current schedules or to indicate fine tune adjustments that may be required due to changing traffic conditions, passenger loads or other factors. Schedule adherence data are usually collected by on-board (ride check) or roadside (point check) field checkers either manually or electronically. Another method involves the National Transit Database Collection (formerly called Section 15) random trip samples. The reliability of the data, however, increases with the number of incidences observed for each trip.

3) Automatic vehicle location (AVL) data

AVL data are available to scheduling personnel in some larger transit systems that have acquired reliable AVL technology. AVL technology is based on one of several locating techniques, including "global positioning" (GPS), "dead-reckoning" and "triangulation" or alternatively, on a network of wayside signpost transponders that communicate with on-board transmitters to estimate vehicle location and provide a corresponding time stamp. Running time data are stored temporarily in on-board computer memory and periodically downloaded or transmitted via radio to a site computer.

4) Vehicle stop inventory

A vehicle stop inventory is a reference document containing information such as the location of bus stops, the position of stops relative to intersections (near side - this side of intersection, far side - across the intersection, or mid-block), the distance between stops, the routes that serve that stop, and a list of street "furniture" (shelters, benches, signs, etc.). The number and location of vehicle stops along the route directly affects the amount of running time needed to travel from one time point to another. Often, the following guidelines are used to estimate the number of stops on a given route segment.

- **Urban settings:** Locate six (6) to eight (8) stops per directional mile, or one every two (2) to three (3) city blocks.
- **Suburban settings:** Locate four (4) to six (6) stops per mile, depending on the availability of intersections, continuity of property development, availability of sidewalks, safe stopping locations and other relevant information.
- **Rural settings:** Posted stops may be infrequent. Flag stops often exist, whereby a passenger is able to signal the vehicle to stop at a location deemed safe for boarding.

5) Extended dwell requirements

Schedules may need to be adjusted to accommodate timed transfer locations, predicted use of a wheelchair lift or bicycle rack equipment, and other activities that may require the vehicle to dwell (stay) at a stop longer than usual.

III. Data Collection Techniques

A variety of collection techniques have been utilized to obtain passenger traffic and vehicle running time data. Many of these techniques allow the field checker to collect both types of information at once. Eight common techniques are presented below.

A. Calculated running time estimates

In cases where field service is proposed, running times are often estimated by projecting average operating speed or driving the proposed service via automobile. Reliability of the estimates can be made by simulating the new service alignment utilizing an out-of-service revenue or training vehicle. Checks can be made to determine if other service alignments overlap the area and running time files are available. Once new service has begun, monitoring running times for accurancy is a good idea to evaluate the accuracy of the original estimates.

B. Point checks

Point checks are an effective way to identify passenger loads and schedule adherence of transit vehicles passing a particular time point(s). The data collected are useful when considering changes in headways on relatively high frequency routes, reallocating running time between time points, or similar schedule fine tuning. The data may be recorded manually on forms or on hand-held data collection devices.

C. Ride checks

Ride checks provide passenger traffic data by stop and running time for an entire trip or set of trips. These data are collected by a checker who rides the vehicle and records passenger boardings and alightings at each stop, as well as on-time performance. The data may be recorded manually on forms or on hand-held programmable calculators.

D. National Transit Database (NTD) checks (formerly Section 15)

NTD checks are special ride checks designed to collect data on one-way trips which are selected at random to comply with Federal grant administration requirements. Although otherwise identical to ride checks, NTD checks are based on random sampling–statistically valid at the system level but not at the route or trip level. Therefore, this information is best used to supplement other data collection efforts.

E. Trail checks

Trail checks are usually conducted by supervisors or checkers in company vehicles that follow the revenue service vehicle in order to observe running times, passenger loading or related issues. The major benefit of a trail check is that the schedule maker or supervisor can observe actual conditions on the street without drawing conclusions from data alone. Trail checks are especially benefical for observing contingent issues such as bus stop conditions and pedestrian access.

F. Farebox and operator counts

Trip counts are collected either with registering fareboxes or denominator button counts taken by vehicle operators while in revenue service. These counts provide general information on passenger traffic, such as total passengers per trip and a distribution of passengers by fare type. In some systems, depending on work rules, operators may also conduct occasional or daily boarding counts.

G. Automated passenger counters and automated vehicle location

APCs, when included as a component of AVL systems, can provide comprehensive ride check and running time data faster than manual methods. APCs are often installed on a limited number of electronically equipped "data buses" that are moved throughout the system to collect data on specific routes, runs or blocks. APCs generally count passengers using either pulse beams mounted in the door stepwells or step treadles. APCs can be used without AVL, although the specific location of each stop and route segmentation can be difficult to ascertain.

H. Operator interviews

Although not always an accurate method of obtaining precise quantitative data, operator interviews are especially helpful for obtaining information necessary for proper schedule adjustment. Operators familiar with a route are a valuable source of information on route safety issues, locations where extended dwell requirements are called for, large volume passenger stops, and transfer needs.

IV. Using Data as a Diagnostic Tool

To maintain schedule reliability and service quality, every schedule, regardless of how well constructed, will require periodical fine tuning. It is generally considered good practice to revisit new or substantially revised schedules after 6 to 12 months of operation. Some schedules may require more timely attention. Cost considerations, passenger complaints and suggestions from operators and supervisors are factors that may prompt more immediate schedule analysis.

The most desirable way to understand how well a schedule is working is by analyzing ridership and running time data over as many days as practical and including personal observations in the field whenever possible. Multi-day analysis helps minimize the chance for improper schedule adjustments resulting from an evaluation based on an unusual event on that route.

A. Example schedule analysis using Route 32

Recap: Route 32 is a peak-only local bus route that operates a 30-minute headway. No midday service is provided. A ride check is conducted to determine ridership and running time on all 18 westbound and 16 eastbound trips. This is done by ride checkers on each of the three A.M. and three P.M. blocks. The data are collected on ride check forms (see earlier example), then transferred into an electronic spreadsheet (see following example of a partially completed summary spreadsheet).

Route 32 / Westbound

TRIP DEPARTS			6:26a				6:56a						
Stop	Sched	Actual	On	Off	LOB	Sched	Actual	On	Off	LOB	.	.	**Total**
Comanche @ Big Sky	6:26a	**6:26**	2	0	2	6:56a	**6:57**	1	0	1			
El Rio			1	0	3			1	0	2			
Portola			5	0	8			1	0	3			
Louisiana			1	0	9			3	0	3			
Davis			1	0	10			2	1	4			
Alta			0	1	9			1	0	5			
Cordoba			1	0	10			3	0	8			
Denali			2	0	12			3	0	11			
Wyoming			0	1	11			4	1	14			
Jones			4	2	13			2	0	16			
.													
.													
TOTAL			**37**	**37**	**0**			**26**	**26**	**0**			**192 192 0**

Example ride check summary spreadsheet

1) Compiling and viewing ride check data

The primary reason to compile ride checks into a summary spreadsheet format is to be able to view, analyze and summarize the data in ways that produce a clear picture of passenger traffic volumes and distributions. The previous spreadsheet presented passenger traffic data and schedule variance by trip and summarized total boardings, alightings and LOBs. Viewing these data by **route segment** allows the scheduler to see

- Where maximum loads occur (LOB data).
- Whether the number of scheduled trips is appropriate for rider demand. (Does the average LOB exceed policy?)
- How passenger loading affects running time and on-time performance. (Does schedule variance increase at high passenger boardings or alightings?)

Viewing these data by **time period** allows the scheduler to see

- Whether the service span is adequate. (Do high passenger volumes exist at the beginning or end of a service period?)
- Whether headways are appropriate for ridership volumes at various hours of the day. (Does the average LOB exceed policy load standards?)

Average schedule variance is a useful method of organizing schedule adherence data collected over a number of days. It is the total number of minutes ahead or behind schedule divided by the number of trips checked. Average schedule variance is often used to analyze a time period, route segment or similarly defined set of trips.

Direction: Westbound
Time Period: A.M. Peak

Route Segment	Number of Trips	Passengers On	Passengers Off	LOB	Average Schedule Variance Segment	Average Schedule Variance Cumulative
1. CBS to COW	8	76	0	76	-1	-1
2. COW to CSM	8	52	23	105	-1	-2
3. CSM to COC	8	66	47	124	-2	-4
4. COC to 4GR	8	70	72	122	+1	-3
5. 4GR to RGM	8	8	130	0	0	-3
Total	8	272	272		-3	-3

Direction: Eastbound
Time Period: A.M. Peak

Route Segment	Number of Trips	Passengers On	Passengers Off	LOB	Average Schedule Variance Segment	Average Schedule Variance Cumulative
1. RGM to 4GR	8	41	5	36	0	0
2. 4GR to COC	8	28	9	55	0	0
3. COC to CSM	8	47	21	81	-2	-2
4. CSM to COW	8	23	27	77	-1	-3
5. COW to CBS	8	14	91	0	-1	-4
Total	8	153	153		-4	-4

Example schedule variance summary by route segment - Route 32 A.M. peak east- and westbound

Direction: Westbound
Time Period: P.M. Peak

Route Segment	Number of Trips	Passengers On	Passengers Off	LOB	Average Schedule Variance Segment	Average Schedule Variance Cumulative
1. CBS to COW	10	38	1	37	-1	-1
2. COW to CSM	10	34	6	65	0	-1
3. CSM to COC	10	50	39	76	-3	-4
4. COC to 4GR	10	32	41	67	+1	-3
5. 4GR to RGM	10	15	82	0	-1	-4
Total	10	169	169		-4	-4

Direction: Eastbound
Time Period: P.M. Peak

Route Segment	Number of Trips	Passengers On	Passengers Off	LOB	Average Schedule Variance Segment	Average Schedule Variance Cumulative
1. RGM to 4GR	8	161	15	146	0	0
2. 4GR to COC	8	67	30	183	-1	-1
3. COC to CSM	8	48	52	179	-2	-3
4. CSM to COW	8	16	105	90	0	-3
5. COW to CBS	8	4	94	0	-1	-4
Total	8	296	296		-4	-4

Example schedule variance summary by route segment - Route 32 P.M. peak east- and westbound

2) Evaluating the data

The schedule maker can make a number of observations from viewing the data in this manner.

- The primary passenger flow is westbound in the morning and eastbound in the afternoon. Morning peak flow trips average 34 total boardings (272 total boardings divided by 8 trips), while afternoon trips average 37 boardings (296 total boardings divided by 8 trips).

- The segment summary data indicate the central transfer point RGM is a significant trip generator, meaning that the accuracy of scheduled arrivals and departures at that point is very important.

- The MLP occurs between the time points COC and CSM in both directions.

- Running time allowed in the current schedule is 3 to 4 minutes too little to ensure 100% on-time performance. At least 2 more minutes are required between COC and CSM. One additional minute is needed between COW and CBS in both directions and during all time periods. Other adjustments appear to be needed in one direction or the other as well as in the A.M. or P.M. peak.

- The data on average passenger loads, starting and ending loads and the presence of significant ridership in both directions suggests that midday service may be justified on this route. (Many transit systems have guidelines and standards on which to base increases or decreases in service).

B. Revising the master schedule for Route 32

It appears that adjustments to Route 32 are in order. The scheduler intends to adjust running times and add base service in accordance with the data collected.

1) Adding base service

The agency has decided to add three midday (base) trips in each direction. It has been determined that these three midday trips will operate on a 1-hour headway. Although the current running times are tight for the peak periods, they appear to be adequate for the midday or base period when demand is not as high.

2) Adjusting running times

The chart below illustrates the adjustments made to the running times for Route 32 Revised. The running time has been increased in both directions during both A.M. and P.M. peak periods. When running time and cycle time are increased, it is important to ensure that layover requirements have not been compromised.

ROUTE 32 (Revised running time file)

Service Day: Weekday

Direction: Westbound

Time Point	A.M. Peak	**Base**	P.M. Peak
Comanche @ Big Sky	-	-	-
Comanche @ Wyoming	~~9~~ **10**	**9**	~~9~~**10**
Comanche @ San Mateo	~~6~~ **7**	**6**	~~6~~ **6**
Comanche @ Carlisle	~~4~~ **6**	**4**	~~4~~ **7**
N. 4th @ Griegos	~~10~~ **9**	**10**	~~10~~**9**
Rio Grande @ Montano	~~7~~ **7**	**7**	~~7~~ **8**
TOTAL	~~36~~**39**	**36**	~~36~~**40**

ROUTE 32 (Revised running time file)

Service Day: Weekday

Direction: Eastbound

Time Point	A.M. Peak	**Base**	P.M. Peak
Rio Grande @ Montano	-	-	-
N. 4th @ Griegos	~~7~~ **7**	**7**	~~7~~ **7**
Comanche @ Carlisle	~~10~~**10**	**10**	~~10~~**11**
Comanche @ San Mateo	~~4~~ **6**	**4**	~~4~~ **6**
Comanche @ Wyoming	~~6~~ **7**	**6**	~~6~~ **6**
Comanche @ Big Sky	~~9~~ **10**	**9**	~~9~~ **10**
TOTAL	~~36~~**40**	**36**	~~36~~**40**

Revised running time file for Route 32

CHAPTER 1: EXERCISES

#1 Given the new running time file, revise the master schedule below for Route 32. For this exercise, assume trips starting between 6:00 a.m. and 10:00 a.m. use A.M. peak running times. Trips starting between 10:01 a.m. and 1:00 p.m. use base running times and trips starting after 1:00 p.m. require P.M. peak running times.

The start times for each A.M., Base and P.M. trip in each direction are already shown on the schedule. (Answer on next page)

ROUTE 32 (Revised running time file)

Service Day: Weekday

Direction: Westbound

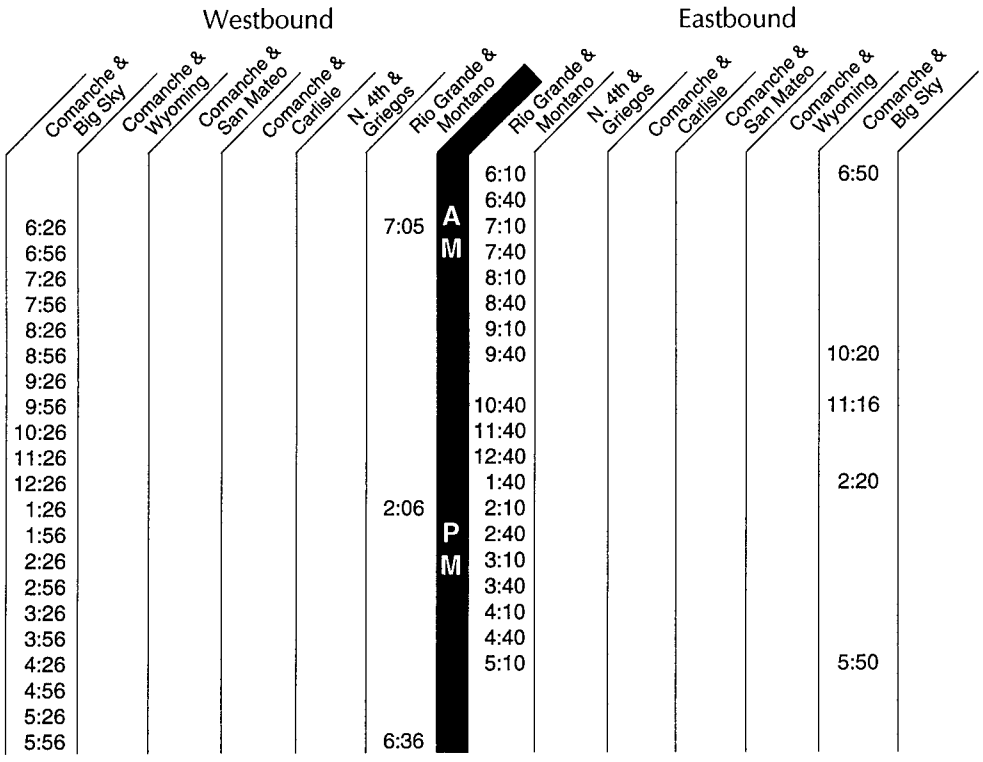
Time Point	A.M. Peak	Base	P.M. Peak
Comanche @ Big Sky	-	-	-
Comanche @ Wyoming	10	9	10
Comanche @ San Mateo	7	6	6
Comanche @ Carlisle	6	4	7
N. 4th @ Griegos	9	10	9
Rio Grande @ Montano	7	7	8
TOTAL	39	36	40

ROUTE 32 (Revised running time file)

Service Day: Weekday

Direction: Eastbound

Time Point	A.M. Peak	Base	P.M. Peak
Rio Grande @ Montano	-	-	-
N. 4th @ Griegos	7	7	7
Comanche @ Carlisle	10	10	11
Comanche @ San Mateo	6	4	6
Comanche @ Wyoming	7	6	6
Comanche @ Big Sky	10	9	10
TOTAL	40	36	40



Revised Master Schedule for Route 32

Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
							6:10	6:17	6:27	6:33	6:40	6:50
							6:40	6:47	6:57	7:03	7:10	7:20
6:26	6:36	6:43	6:49	6:58	7:05	A	7:10	7:17	7:27	7:33	7:40	7:50
6:56	7:06	7:13	7:19	7:28	7:35	M	7:40	7:47	7:57	8:03	8:10	8:20
7:26	7:36	7:43	7:49	7:58	8:05		8:10	8:17	8:27	8:33	8:40	8:50
7:56	8:06	8:13	8:19	8:28	8:35		8:40	8:47	8:57	9:03	9:10	9:20
8:26	8:36	8:43	8:49	8:58	9:05		9:10	9:17	9:27	9:33	9:40	9:50
8:56	9:06	9:13	9:19	9:28	9:35		9:40	9:47	9:57	10:03	10:10	10:20
9:26	9:36	9:43	9:49	9:58	10:05							
9:56	10:06	10:13	10:19	10:28	10:35		10:40	10:47	10:57	11:01	11:07	11:16
10:26	10:35	10:41	10:45	10:55	11:02		11:40	11:47	11:57	12:01	12:07	12:15
11:26	11:35	11:41	11:45	11:55	12:02		12:40	12:47	12:57	1:01	1:07	1:16
12:26	12:35	12:41	12:45	12:55	1:02		1:40	1:47	1:58	2:04	2:10	2:20
1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50
1:56	2:06	2:12	2:19	2:28	2:36	P	2:40	2:47	2:58	3:04	3:10	3:20
2:26	2:36	2:42	2:49	2:58	3:06	M	3:10	3:17	3:28	3:34	3:40	3:50
2:56	3:06	3:12	3:19	3:28	3:36		3:40	3:47	3:58	4:04	4:10	4:20
3:26	3:36	3:42	3:49	3:58	4:06		4:10	4:17	4:28	4:34	4:40	4:50
3:56	4:06	4:12	4:19	4:28	4:36		4:40	4:47	4:58	5:04	5;10	5:20
4:26	4:36	4:42	4:49	4:58	5:06		5:10	5:17	5:28	5:34	5:40	5:50
4:56	5:06	5:12	5:19	5:28	5:36							
5:26	5:36	5:42	5:49	5:58	6:06							
5:56	6:06	6:12	6:19	6:28	6:36							

#2 Re-block the revised master schedule for Route 32. The ORIGINAL blocking scheme is shown below as reference. (Answer on the next page)

	Westbound							Eastbound						
Block/Trip#	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky	
3203-01	6:26	6:35	6:41	6:45	6:55	7:02	▒							
3201-02	6:56	7:05	7:11	7:15	7:25	7:32	●	6:10	6:17	6:27	6:31	6:37	6:46 ●	3201-01
3202-02	7:26	7:35	7:41	7:45	7:55	8:02	○	6:40	6:47	6:57	7:01	7:07	7:16 ○	3202-01
3203-03	7:56	8:05	8:11	8:15	8:25	8:32	▒	7:10	7:17	7:27	7:31	7:37	7:46 ▒	3203-02
3201-04	8:26	8:35	8:41	8:45	8:55	9:02	●	7:40	7:47	7:57	8:01	8:07	8:16 ●	3201-03
3202-04	8:56	9:05	9:11	9:15	9:25	9:32	○	8:10	8:17	8:27	8:31	8:37	8:46 ○	3202-03
3203-05	9:26	9:35	9:41	9:45	9:55	10:02	▒	8:40	8:47	8:57	9:01	9:07	9:16 ▒	3203-04
3201-06	9:56	10:05	10:11	10:15	10:25	10:32	●	9:10	9:17	9:27	9:31	9:37	9:46 ●	3201-05
								9:40	9:47	9:57	10:01	10:07	10:16 ○	3202-05
3204-01	1:26	1:35	1:41	1:45	1:55	2:02	●							
3206-01	1:56	2:05	2:11	2:15	2:25	2:32	▒	1:40	1:47	1:57	2:01	2:07	2:16 ○	3205-01
3205-02	2:26	2:35	2:41	2:45	2:55	3:02	○	2:10	2:17	2:27	2:31	2:37	2:46 ●	3204-02
3204-03	2:56	3:05	3:11	3:15	3:25	3:32	●	2:40	2:47	2:57	3:01	3:07	3:16 ▒	3206-02
3206-03	3:26	3:35	3:41	3:45	3:55	4:02	▒	3:10	3:17	3:27	3:31	3:37	3:46 ○	3205-03
3205-04	3:56	4:05	4:11	4:15	4:25	4:32	○	3:40	3:47	3:57	4:01	4:07	4:16 ●	3204-04
3204-05	4:26	4:35	4:41	4:45	4:55	5:02	●	4:10	4:17	4:27	4:31	4:37	4:46 ▒	3206-04
3206-05	4:56	5:05	5:11	5:15	5:25	5:32	▒	4:40	4:47	4:57	5:01	5:07	5:16 ○	3205-05
3205-06	5:26	5:35	5:41	5:45	5:55	6:02	○	5:10	5:17	5:27	5:31	5:37	5:46 ●	3204-06
3204-07	5:56	6:05	6:11	6:15	6:25	6:32	●							

	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
3201								6:10	6:17	6:27	6:32	6:40	6:50
3202								6:40	6:47	6:57	7:03	7:10	7:20
3203	6:26	6:36	6:43	6:49	6:58	7:05	A	7:10	7:17	7:27	7:33	7:40	7:50
3201	6:56	7:06	7:13	7:19	7:28	7:35	M	7:40	7:47	7:57	8:03	8:10	8:20
3202	7:26	7:36	7:43	7:49	7:58	8:05		8:10	8:17	8:27	8:33	8:40	8:50
3203	7:56	8:06	8:13	8:19	8:28	8:35		8:40	8:47	8:57	9:03	9:10	9:20
3201	8:26	8:36	8:43	8:49	8:58	9:05		9:10	9:17	9:27	9:33	9:40	9:50
3202	8:56	9:06	9:13	9:19	9:28	9:35		9:40	9:47	9:57	10:03	10:10	10:20
3203	9:26	9:36	9:43	9:49	9:58	10:05							
3201	9:56	10:06	10:13	10:19	10:28	10:35		10:40	10:47	10:57	11:01	11:07	11:16
3202	10:26	10:35	10:41	10:45	10:55	11:02		11:40	11:47	11:57	12:01	12:07	12:15
3201	11:26	11:35	11:41	11:45	11:55	12:02		12:40	12:47	12:57	1:01	1:07	1:16
3202	12:26	12:35	12:41	12:45	12:55	1:02		1:40	1:47	1:58	2:04	2:10	2:20
3201	1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50
3204	1:56	2:06	2:12	2:19	2:28	2:36	P	2:40	2:47	2:58	3:04	3:10	3:20
3202	2:26	2:36	2:42	2:49	2:58	3:06	M	3:10	3:17	3:28	3:34	3:40	3:50
3201	2:56	3:06	3:12	3:19	3:28	3:36		3:40	3:47	3:58	4:04	4:10	4:20
3204	3:26	3:36	3:42	3:49	3:58	4:06		4:10	4:17	4:28	4:34	4:40	4:50
3202	3:56	4:06	4:12	4:19	4:28	4:36		4:40	4:47	4:58	5:04	5;10	5:20
3201	4:26	4:36	4:42	4:49	4:58	5:06		5:10	5:17	5:28	5:34	5:40	5:50
3204	4:56	5:06	5:12	5:19	5:28	5:36							
3202	5:26	5:36	5:42	5:49	5:58	6:06							
3201	5:56	6:06	6:12	6:19	6:28	6:36							

New blocking configuration for revised Route 32

With the addition of the midday service, the original Route 32 A.M. blocks 3201 and 3202 remain in service and hook into the midday trips. A.M. block 3203 remains a peak only block with the same start and end times.

Extended blocks 3201 and 3202 (now referred to as base or all day blocks) are shown continuing into the P.M. peak and hooking into former P.M. blocks 3204 and 3205 respectively. Original P.M. block 3206 still begins and ends at the same times, however is renumbered as 3204 in the revised Route 32 schedule in order to maintain a pattern of consecutive block numbering.

Finally, note that since the midday service operates hourly, considerable excess layover exists at Rio Grande & Montano at the midday hooks.

Notes:

CHAPTER 2

TRIP GENERATION

Advanced Section

I. Introduction

A number of factors influence the complexity of a schedule, including the number of vehicles on the route; changes in the headway between peak, base, evening and night service; route branches; short turns; timed transfers; changes in the controlling time point(s) and travel direction(s); special trips; school trippers, interlined trips and agency work rules and stipulations.

To address these and other scheduling considerations, a variety of intermediate and advanced scheduling techniques are presented in this chapter on trip generation. For illustration, a hypothetical Route 110, considered a complex local route, will serve as a model. The development of Route 110, along with newly revised Route 32, will continue as models for subsequent chapters on Blocking (Chapter 3), Runcutting (Chapter 4) and Rostering (Chapter 5).

The process for trip generation presented in this chapter will generally follow these steps:

- Understanding how route design relates to service area characteristics
- Defining route patterns
- Calculating and optimizing cycle time
- Investigating branch interlining
- Drafting a route diagram
- Calculating running times and number of vehicles
- Determining and transitioning between controlling time points
- Pull-on and pull-off points and strategies
- Optimizing
- Developing the master schedule

II. Route Design and the Master Schedule

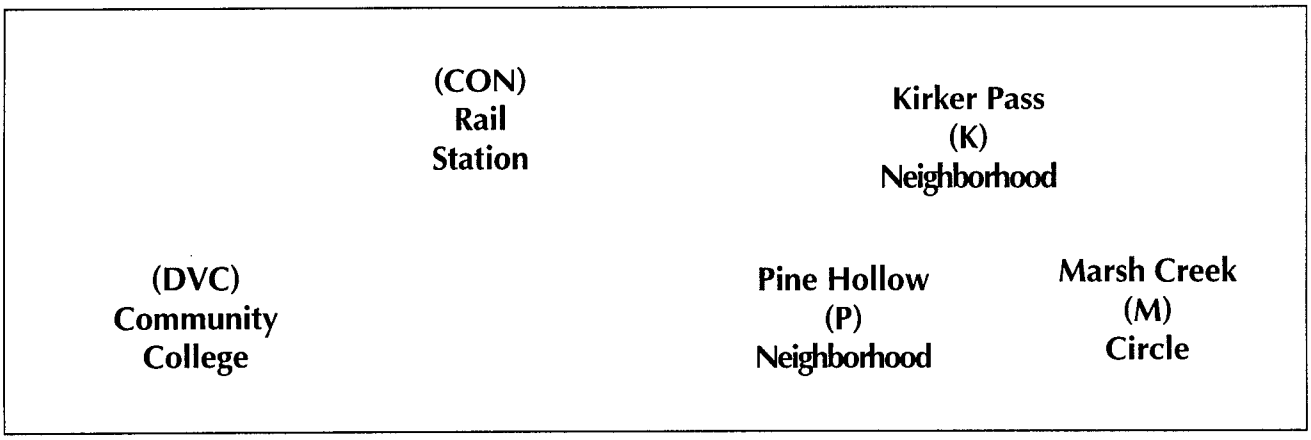
Service Area

The functional role of Route 110 is to connect several miles of residential neighborhoods and subdivisions that stretch along the main road (Clayton) at the eastern end of the service area, with numerous local commercial destinations, a commuter rail station and a community college campus (DVC), all of which are concentrated in the western end of the service area.

Both a high school and a middle school are located in the eastern neighborhoods. However, there is no strong commercial anchor to serve as the eastern terminal, making looping through these major subdivisions the most apparent option. The three neighborhood areas (and their branch definition) are

1) Kirker Pass (K),
2) Pine Hollow (P), and
3) Marsh Creek (M).

The commuter rail station (CON) is located mid-route. The community college campus (DVC) is the logical choice for western terminus, at which transfers to other routes are possible.



Service area planned for Route 110

Service Design Guidance

Route 110 has substantial peak period ridership potential due primarily to the large number of neighborhood commuters needing to access the rail station before 7:30 a.m. Service on the trunk is therefore planned to operate every 10 minutes during peak hours, every 20 minutes during off-peak hours and every 30 minutes at night. Up to three branches may be used to serve the residential subdivisions at the eastern end of the route.

III. Route Pattern

As complexities are planned into a new or restructured route, the scheduler is challenged to create a route pattern which ensures that vehicle hours and miles are distributed as effectively as possible. The Route 110 pattern above defines how each of the three planned branches will be served. Passengers tend to be better served when the pattern generates predictable "through-service connections" in both directions.

Before beginning the trip building process, the scheduler must decide which vehicles from the trunk line will operate over which branch. Based on the available information, the preliminary decision is made to alternate the trips evenly across the three branches.

IV. Optimizing Cycle Time

When the branches are of different lengths and running times, the scheduler can investigate the option of hooking long and short trips together to achieve more balanced cycle times. Otherwise, a vehicle making two long trips could result in maximum cycle time while a vehicle making two shorter trips could lead to minimum cycle time.

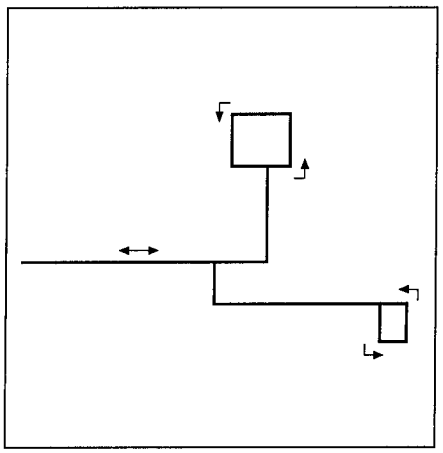
For example: When route branches are of unequal length, the following combination of trips may help balance the cycle time:

First vehicle:	Trunk + Long Branch + Trunk + Short Branch
Second vehicle:	Trunk + Short Branch + Trunk + Long Branch

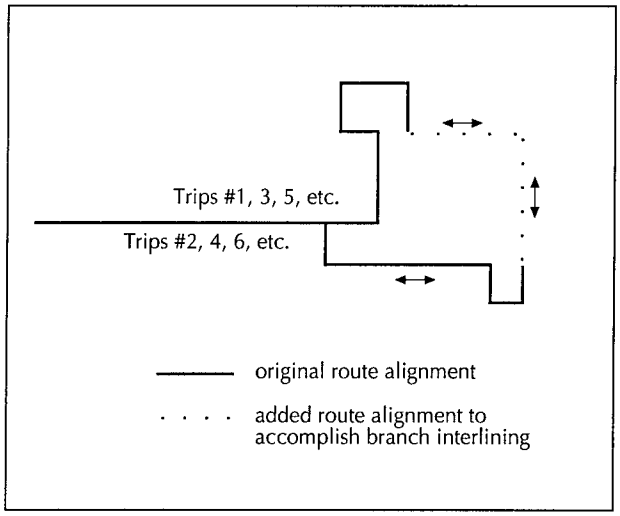
Other strategies could also optimize cycle time, such as combining all short trips together as well as combining all long trips together to produce more efficent blocks.

V. Branch Interlining

Branch interlining is often employed as an alternative to one-way looping through residential areas in order to "end" a route. In many cases, two route branches that serve adjacent residential neighborhoods can be interlined through a common outer time point. This means that the outbound trip of one branch is hooked to the inbound trip of another branch, rather than turned back on itself (on the same branch) at the terminal time point.



Route branches using one-way terminating loop operation



Route branches using branch interlining

Interlining the two branches creates a single, larger loop serving both directions on most segments of the branches. This has three distinct advantages when considered for Route 110.

1) It tends to balance the running times required to maintain service on each branch.

2) Operating vehicles in both directions along the same neighborhood streets provides opportunities for local circulation within the neighborhoods. Independent one-way loops would not provide that opportunity.

3) It allows for more efficient spacing of vehicles. Turning buses back at an arbitrary point and following the same route back to the trunk line would not provide that opportunity.

The area covered by the eastern segment of Route 110 is dominated by residential subdivisions linked by minor arterials and collector streets. There is little commercial development or other land use conducive to vehicle layovers.

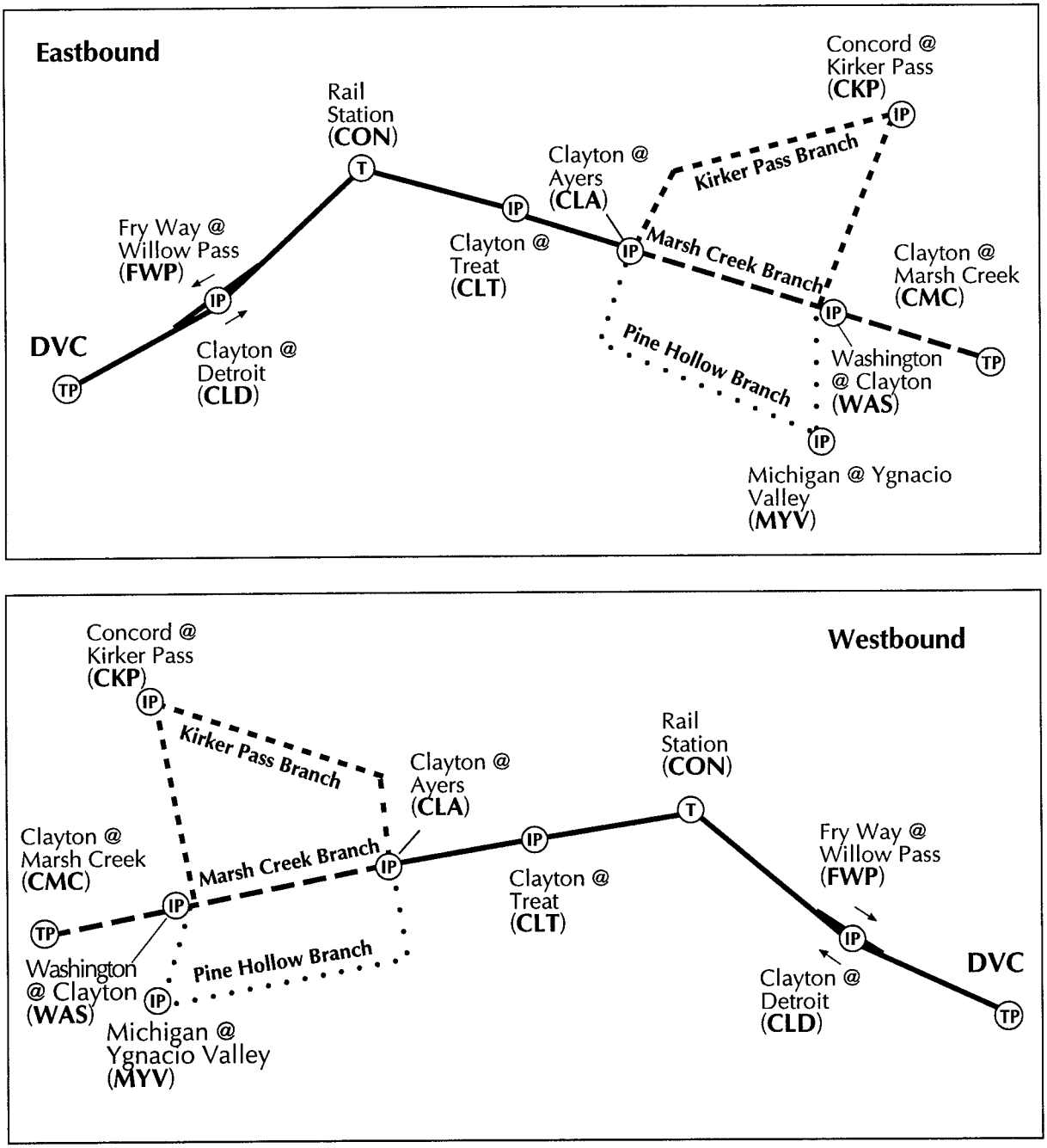
Interlining outbound K and inbound P trips, and outbound P and inbound K trips generates effective internal circulation between adjacent residential subdivisions. This linkage is particularly useful to students attending the middle and high schools located along the Pine Hollow branch.

Branch interlining appears to be an effective way to handle two of the three neighborhoods at the eastern end of Route 110.

VI. Using Route Diagrams

Many schedulers find it useful to create a diagram of the trunk and branches of complex routes. This usually helps when laying out the time points in the master schedule.

Sample route diagrams of Route 110 in the eastbound and westbound directions are provided below.



Route diagrams for Route 110 by direction

IP Intermediate Point
TP Terminal Point
T Timed Transfer Terminal

The route diagrams show timed transfer terminals (T), terminal time points (TP), intermediate time points (IP), and the trunk and branches of the route. Running time between time points can also be added, and controlling time point(s) can be noted as well.

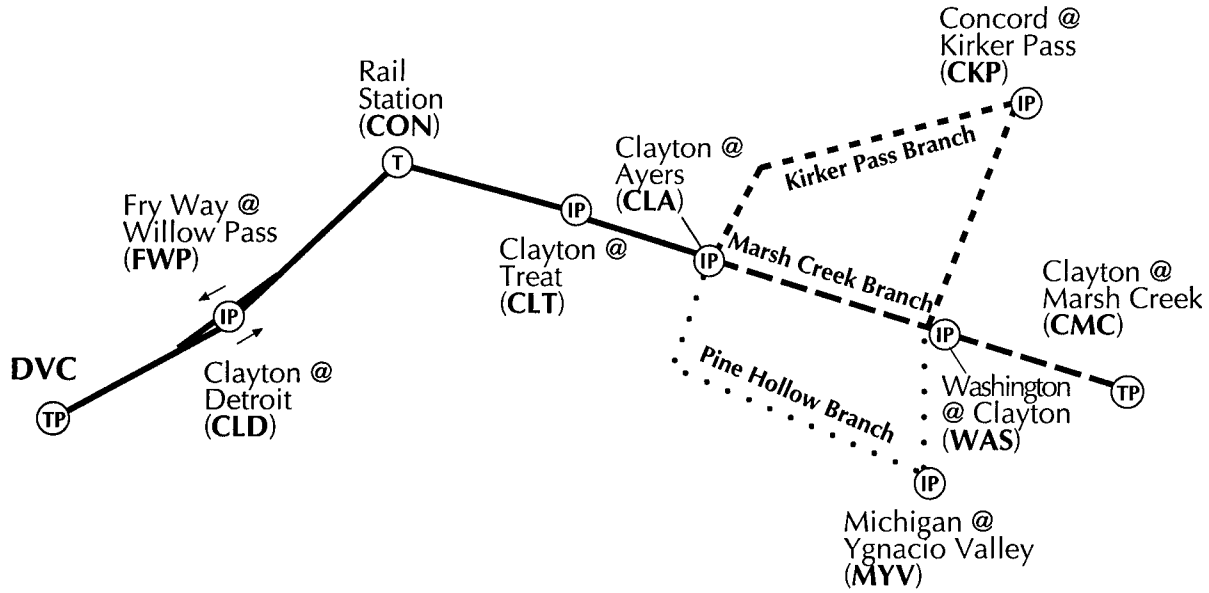
The diagrams indicate that there is a trunk (DVC to Clayton @ Ayers) and three branches at the eastern end of the route:

Kirker Pass	(K)	- - - -
Pine Hollow	(P)	. . . .
Marsh Creek	(M)	— —

Both the K and P branches are designed to use the same terminal end point at the intersection of Washington @ Clayton (WAS). This allows for branch interlining as follows:

- Eastbound Kirker Pass (K) trips return as westbound Pine Hollow (P) trips
- Eastbound Pine Hollow (P) trips return as westbound Kirker Pass (K) trips

The third branch serving Marsh Creek (M) runs two-way service along a linear alignment into Marsh Creek Circle.



Three defined patterns for Route 110

Interlining two of the three branches means that three route patterns are now defined as follows:

Combination Number	Round Trip Trunk/Branch Combinations
1	Eastbound trunk + eastbound K branch + westbound P branch + westbound trunk
2	Eastbound trunk + eastbound P branch + westbound K branch + westbound trunk
3	Eastbound trunk + eastbound M branch + westbound M branch + westbound trunk

VII. Cycle and Running Times

Cycle time is the total number of minutes needed to make a round trip in revenue service, plus any layover and recovery time at both ends of the line. For Route 110, cycle time is the time required for a vehicle to travel from DVC eastbound to Clayton @ Ayers, continue on one of the three branches to an eastern terminal, layover, and then return to DVC and layover again.

To determine round trip running time for Route 110, it is important to first understand the various patterns that will be used in the development of the master schedule.

The running time files that follow illustrate running times between time point pairs for each of ***seven defined time periods***. Time periods are customized to the needs of the local transit agency. Note that running times vary not only by time period, but also by branch. To calculate maximum cycle time, the longest combination of eastbound and westbound one-way trips must be used for each time period. As expected, the longest cycle time occurs during the morning and afternoon peak periods when transit ridership and general traffic volumes are highest.

ROUTE 110 EASTbound
Running Time File

Service Day: Weekday
Direction: Eastbound

Time Period/Point	*Early A.M.*	*A.M. Peak*	*Base*	*School*	*P.M. Peak*	*Evening*	*Night*
From:	4:30a	5:31a	8:31a	2:01p	4:01p	7:01p	10:01
Until:	5:30a	8:30a	2:00p	4:00p	7:00p	10:00p	11:59p
ALL TRIPS							
DVC	-	-	-	-	-	-	-
Clayton@Detroit (CLD)	10	11	11	13	13	11	11
Rail Station (CON)	6	7	6	7	8	7	6
Clayton@Treat (CLT)	6	8	8	9	10	7	7
Clayton@Ayers (CLA)	4	5	5	6	7	5	5
VIA KIRKER PASS (K)							
Concord@Kirker Pass (CKP)	4	4	4	5	5	4	4
Washington@Clayton (WAS)	7	9	8	9	10	8	8
VIA PINE HOLLOW (P)							
Michigan@Ygnacio Valley (MYV)	4	5	4	5	5	4	4
Washington@Clayton (WAS)	7	8	7	9	8	7	7
VIA MARSH CREEK CIRCLE (M)							
Washington@Clayton (WAS)	3	4	3	4	3	3	3
Clayton@Marsh Creek (CMC)	8	8	8	8	14	12	12
Total via K	37	44	42	49	53	42	41
Total via P	37	44	41	49	51	41	40
Total via M	37	43	41	47	55	45	44

Running time file for eastbound Route 110

ROUTE 110 WESTbound
Running Time File

Service Day: Weekday
Direction: Westbound

Time Period/Point	*Early A.M.*	*A.M. Peak*	*Base*	*School*	*P.M. Peak*	*Evening*	*Night*
From:	4:30a	5:31a	8:31a	2:01p	4:01p	7:01p	10:01
Until:	5:30a	8:30a	2:00p	4:00p	7:00p	10:00p	11:59p
VIA KIRKER PASS (K)							
Washington@Clayton (WAS)	-	-	-	-	-	-	-
Concord@Kirker Pass (CKP)	9	9	9	9	9	9	8
Clayton@Ayers (CLA)	4	5	4	5	5	4	4
VIA PINE HOLLOW (P)							
Washington@Clayton (WAS)	-	-	-	-	-	-	-
Michigan@Ygnacio Valley (MYV)	7	8	7	9	8	7	7
Clayton@Ayers (CLA)	4	5	4	4	4	4	4
VIA MARSH CREEK CIRCLE (M)							
Clayton@Marsh Creek (CMC)	-	-	-	-	-	-	-
Clayton@Ayers (CLA)	14	14	12/11	8	8	8	8
ALL TRIPS							
Clayton@Treat (CLT)	5	6	5	6	6	5	5
Rail Station (CON)	8	9	9	10	10	8	8
Fry Way@Willow Pass (FWP)	5	6	6/5	5	6	5	5
DVC	11	12	13	13/12	13	11	11
Total via K	42	47	46	48	49	42	41
Total via P	40	46	44	47	47	40	40
Total via M	43	47	45	42	43	37	37

Running time file for westbound Route 110

The running time tables show that among eastbound Route 110 trips, the longest running time occurs during the P.M. peak period. Running times range from 51 minutes for trips on the P branch, to 53 minutes for K trips, to 55 minutes for the M trips.

Among westbound trips, the longest running times also occur during the P.M. peak. Running times range from 49 minutes for K trips, to 47 minutes for P trips, to 43 minutes for M trips.

Maximum round trip running time for P.M. peak trips that originate at DVC, operate eastbound via K, westbound via P and return to DVC is ***100 minutes*** (53 minutes eastbound and 47 minutes westbound).

For trips that follow P eastbound and K westbound, maximum round trip running time is also ***100 minutes*** (51 minutes eastbound and 49 minutes westbound).

For M trips in both directions, maximum round trip running time is ***98 minutes*** (55 minutes eastbound and 43 minutes westbound) during the P.M. peak.

VIII. Calculating the Number of Vehicles from the Cycle Time

In addition to round trip running time, cycle time includes layover and recovery time for the round trip. This agency has work rules that establish target layover and recovery time per round trip as follows:

Layover time (min.)	All	4
Recovery time (min.)	A.M. Peak	5
	P.M. Peak	6
	Base	9

The number of vehicles needed to operate service is determined by the equation on the right.

$$\text{\# of Vehicles} = \frac{\text{Cycle Time}}{\text{Headway}}$$

Using P.M. peak for the first computation:
Cycle time is determined to be 110 minutes (100 minutes maximum running time plus 4 minutes layover plus 6 minutes recovery).

The headway for both A.M. and P.M. peak is 10 minutes. Base service is scheduled at 20 minute headways. Therefore 11 vehicles are needed to operate P.M. peak service.

$$\mathbf{11} = \frac{110}{10}$$

Calculating Required Number of Vehicles

Given maximum running times of 91 minutes for A.M. peak service (44 minutes P eastbound plus 47 minutes K westbound) and 87 minutes maximum running time for base service (41 minutes P eastbound plus 46 minutes K westbound), the number of vehicles is 10 and 5, respectively.

The table on the following page summarizes the calculation.

(minutes)	A.M. Peak	P.M. Peak	BASE
Running Time (RT)	91	100	87
Maximum Rail Layover	9	6	5
Maximum Recovery Time	0	4	8
Cycle Time	100	110	100
Trunk Headway	10	10	20
# of Vehicles Required	**10**	**11**	**5**

Route 110 - Maximum number of vehicles required by time period

IX. Controlling Time Points

It is the responsibility of the scheduler to decide not only *where* buses go, but *when* they go there as well. Determining the timing of one or a series of trips is accomplished with the aid of particular point(s) along the route appropriately called controlling time points. Controlling time points are especially important because arrival and departure times at these points can also affect the coordination of trips on one or more intersecting routes.

Controlling time points are usually major traffic generators where a significant number (or flow) of passengers require service at specific times. Office parks, factories and schools are examples of key locations that are often used as controlling time points. Timed transfer points and intermodal transfer facilities are also commonly used as controlling time points.

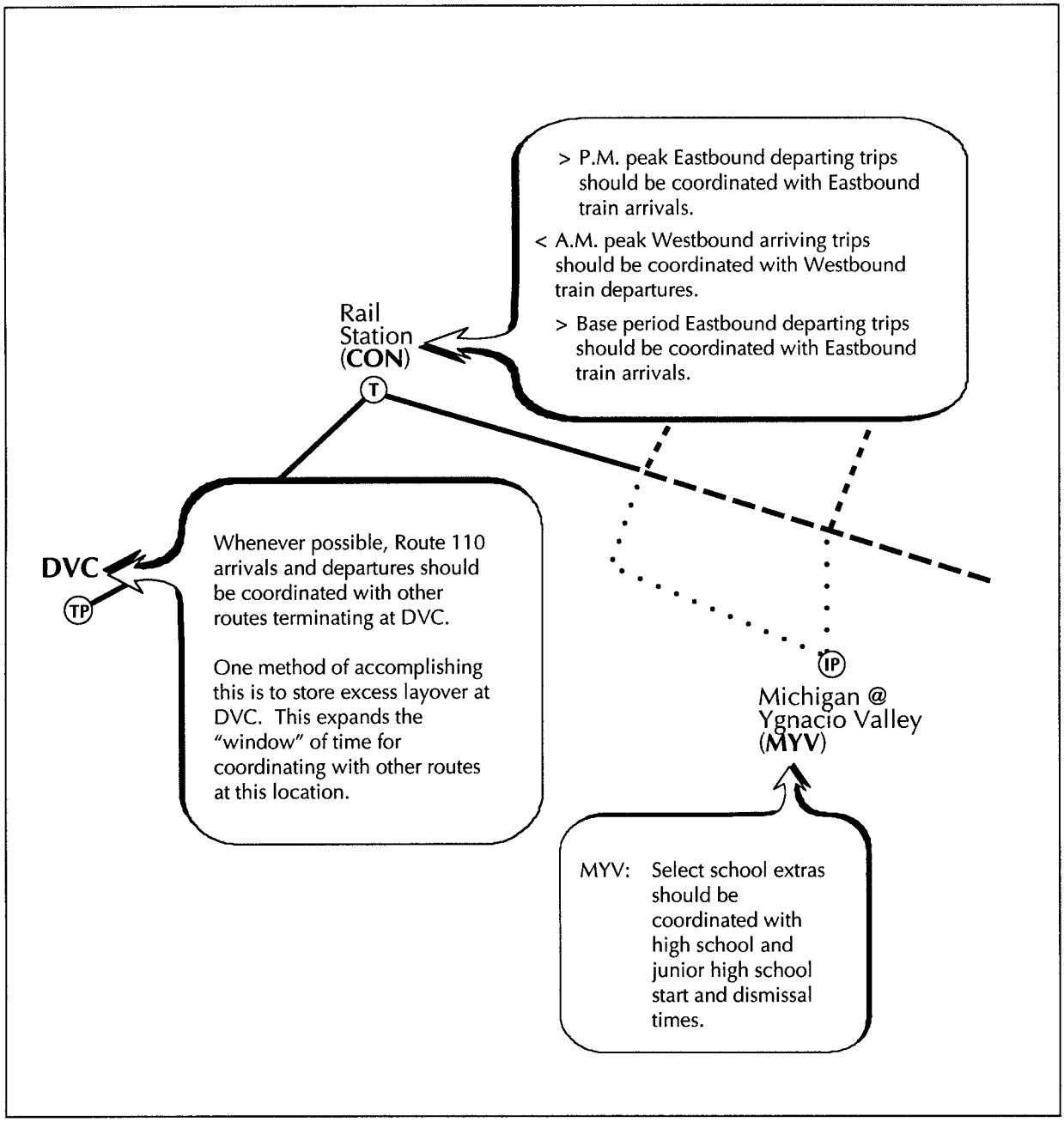
A route may contain one or more controlling time points. However, seldom can two be used at the same time (i.e., on the same trip). This is true because once an arrival or departure time is fixed at a given time point, the times at every other time point in the trip become fixed as well. Recovery time at the route terminal may be used to alter the schedule of the return trip by a few minutes, but often not enough to meet the requirements of a second controlling time point.

Route 110 is influenced by several controlling time points. A very significant controlling time point is the commuter rail station (CON). The regular scheduling practice of the transit agency is to coordinate bus and train arrival and departure times, in both directions whenever possible. Note that the rail station is an intermediate time point rather than a terminal point.

A secondary controlling time point for Route 110 is DVC, the western route terminal. Although it is desirable to schedule timed transfers with the arrivals and departures of other routes serving DVC, it may not be possible to achieve this throughout the day, assuming the dominant influence of the rail station on the Route 110 schedule.

One way to enhance the opportunity for schedule coordination at DVC is to concentrate recovery time at this point. This also expands the window of time during which other routes could meet and coordinate with Route 110 trips.

A third important controlling time point is relevant during morning and afternoon school bell hours. Route 110 serves significant high school and middle school traffic on the K and P branches of the route.



Controlling time points for Route 110

X. Pull-On/Off Points

One final piece of information is needed before beginning the process of generating trips–determining those points where buses *pull on* and *pull off* the route. One or more locations may be used to add or remove vehicles from scheduled service. These locations may be at either or both terminals or at an intermediate time point. The primary factors in determining pull on/off points are distance and travel time from the facility where the vehicles are stored. The desire is to minimize the deadhead time between the points.

In the example of Route 110, both the western terminal DVC and the rail station CON will be used to add and remove peak vehicles to the schedule, given their close proximity to the garage facility.

XI. Developing the Master Schedule

Service Design Guidance

The service day is planned to begin with a 15-minute trunk headway in the early A.M. and rapidly transition to 10-minutes for the A.M. peak. Each branch would have a 30-minute peak headway. The trunk headway spreads to 20 minutes during the base and much of the school period, and then back to 10 minutes for the P.M. peak. The trunk headway will return to 20 minutes during the evening hours and spread to 30 minutes near the end of the service day (night).

Schedulers can use one of several approaches to generating trips. A chronological approach is used in this example. This means that groups of trips will be built consecutively for each time period, by direction, starting with the first early A.M. and A.M. peak trips in the westbound direction.

A. Beginning the service day

The design objective is for five successive westbound arrivals at the rail station at 15-minute intervals between 5:30 a.m. until 6:30 a.m. During this hour, the headway is linked to morning train departures, which occur every 15 minutes.

By constructing trip 1W to leave Washington @ Clayton (WAS) at 5:04 a.m., this first westbound trip arrives at the rail station (CON) at 5:30 a.m. and arrives at the western terminal DVC at 5:49 a.m. (see running time files for computing time point arrival times). Four more westbound trips (two via P, one each from M and K) arrive at CON within the targeted time period. Trips 1W through 5W are consistent with the design objective.

NOTE: Completed Master Schedules, by direction, can be found at the end of this chapter.

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49
2W	P		5:21	5:28		5:32	5:37	**5:45**	5:48	5:53	6:04
3W	K		5:31		5:40	5:45	5:51	**6:00**	6:03	6:09	6:21
4W	M	5:43	5:57			6:00	6:06	**6:15**	6:18	6:24	6:36
5W	P		6:02	6:10		6:15	6:21	**6:30**	6:33	6:39	6:51

The first five westbound trips meet the early morning design objective.

The **controlling time point** during this period of the day is the rail station (Arr CON). This corresponds to the prevailing flow of westbound commuters wanting service to the rail line.

Note that the first M branch trip is trip 4W rather than 3W. Although inconsistent with the plan to alternate trips between the three branches, the M branch is skipped in the early morning due to the determination that service to this area is not required during this time period. Modifications to the rotation of branch service are not uncommon when overall service can be enhanced.

B. Transition to A.M. peak

At 6:30 a.m., the planned headway reduces to 10 minutes between westbound arrivals at CON. However, westbound trains depart toward downtown every 7.5 minutes during this time period. Experienced schedulers recognize that this decision results in less that perfect schedule coordination. From a scheduling perspective, it would be preferable to either 1) reduce the bus headway from 15 minutes to 7.5 minutes (equal to the train station departures), or 2) leave the headway at 15 minutes to meet every other train.

However, the decision to reduce the headway to 10 minutes is a compromise to avoid the additional cost of a reduction all the way to 7.5 minutes and the desire to operate whole minute "clock" headways for customer convenience.

Observation Anticipating the impact of the schedule for a particular set of trips allows the scheduler an opportunity to address the possible consequences, including adverse passenger reaction. In this case, two questions are considered before the next set of trips is constructed:

1) After arriving at CON, how long will passengers wait for the next train?

2) Will passengers arrive just in time to see a train leaving and be frustrated?

Given a 10-minute clock headway, the following would occur:

Arrival #	Bus Arrives	Train Departs	Wait Time
1	6:30a	6:33a	3
2	6:40a	6:40.5a	0
3		6:48a	8
4	6:50a	6:55.5a	5
5	7:00a	7:03a	3
6	7:10a	7:10.5a	0
7		7:18a	8
8	7:20a	7:25.5a	5
9	7:30a	7:33a	3

Anticipating wait time for bus arrival and train departure

The scheduler knows that it takes approximately 3 minutes to comfortably alight the bus, move through the station and board the train. Arrival numbers 2 and 6 could likely generate complaints because arriving passengers observe trains departing before they can get there. Arrival numbers 1, 5 and 9 may also generate similar complaints if they repeatedly arrive behind schedule.

Conclusion Given the relatively high frequency of both bus arrivals (10 minutes) and train departures (7.5 minutes) during this time period, it is determined not to meet every train with a bus arrival. Given a maximum wait of 8 minutes, the decision is made to maintain the 10-minute headway.

Other options Delay the arrival times of 2 and 6 by 1 to 2 minutes
Accelerate arrivals 1 and 9 by 1 to 2 minutes.

Trips 6W through 12W are constructed to deliver the desired 10-minute headway through 7:40 a.m.

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
6W	K		6:11		6:20	6:25	6:31	**6:40**	6:43	6:49	7:01
7W	M	6:18	6:32			6:35	6:41	**6:50**	6:55	7:01	7:13
8W	P		6:32	6:40		6:45	6:51	**7:00**	7:05	7:11	7:23
9W	K		6:41		6:50	6:55	7:01	**7:10**	7:15	7:21	7:33
10W	M	6:48	7:02			7:05	7:11	**7:20**	7:25	7:31	7:43
11W	P		7:02	7:10		7:15	7:21	**7:30**	7:35	7:41	7:53
12W	K		7:11		7:20	7:25	7:31	**7:40**	7:45	7:51	8:03

Second set of westbound trips

Some schedulers continue writing all trips in one direction before moving on to the opposite direction trips. Others prefer to write groups of trips in alternating directions by time period. The latter practice is used in this example.

Thus far, the first 12 westbound trips covering the early A.M. and A.M. peak periods have been built. The eastbound counterparts will be developed with consideration to "hooking" westbound trips to eastbound trips. This procedure will ensure that no more than the planned number of vehicles will be required to operate the schedule.

Hooking is the process of tying one-way trips together to form vehicle blocks. (Refer to Chapter 3 for more detailed discussion of blocking.) Hooking can be done after the entire master schedule has been developed or it can be done concurrent with master schedule development to help fine tune trips and ensure the efficient utilization of vehicles.

The timing of the first eastbound trip is affected by three considerations:

1) It is desirable to hook to trip 1W, which departs WAS at 5:04 a.m.

2) It should support the desired branch pattern described earlier in this segment.

   Note: Recall that pattern for the branches - westbound K trips return as eastbound P trips and eastbound K trips return as westbound P trips.

   Therefore, the first eastbound trip should follow P.

3) Since the trip will be operated by a vehicle pulling onto the line from the vehicle garage facility, it should enter revenue service efficiently at one of the two designated pull on points.

Trip 1E below satisfies these conditions.

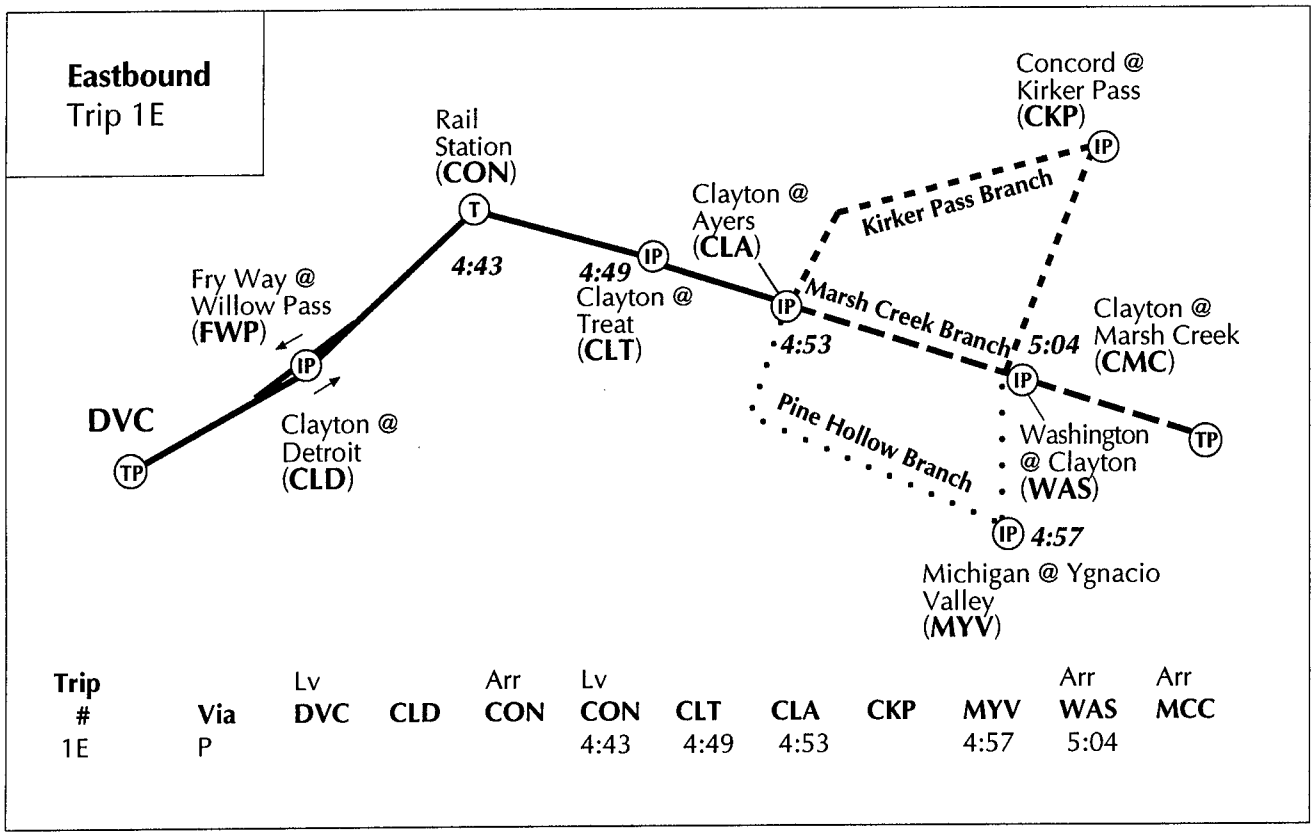
Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P				4:43	4:49	4:53		4:57	5:04	

Trip 1E arrives at WAS at 5:04 a.m. and immediately proceeds as (hooks to) trip 1W.

Trip #	*Via*	*Lv MCC*	*Lv WAS*	*MYV*	*CKP*	*CLA*	*CLT*	*Arr CON*	*Lv CON*	*FRY*	*Arr DVC*
1W	*K*		*5:04*		*5:13*	*5:17*	*5:22*	***5:30***	*5:33*	*5:38*	*5:49*

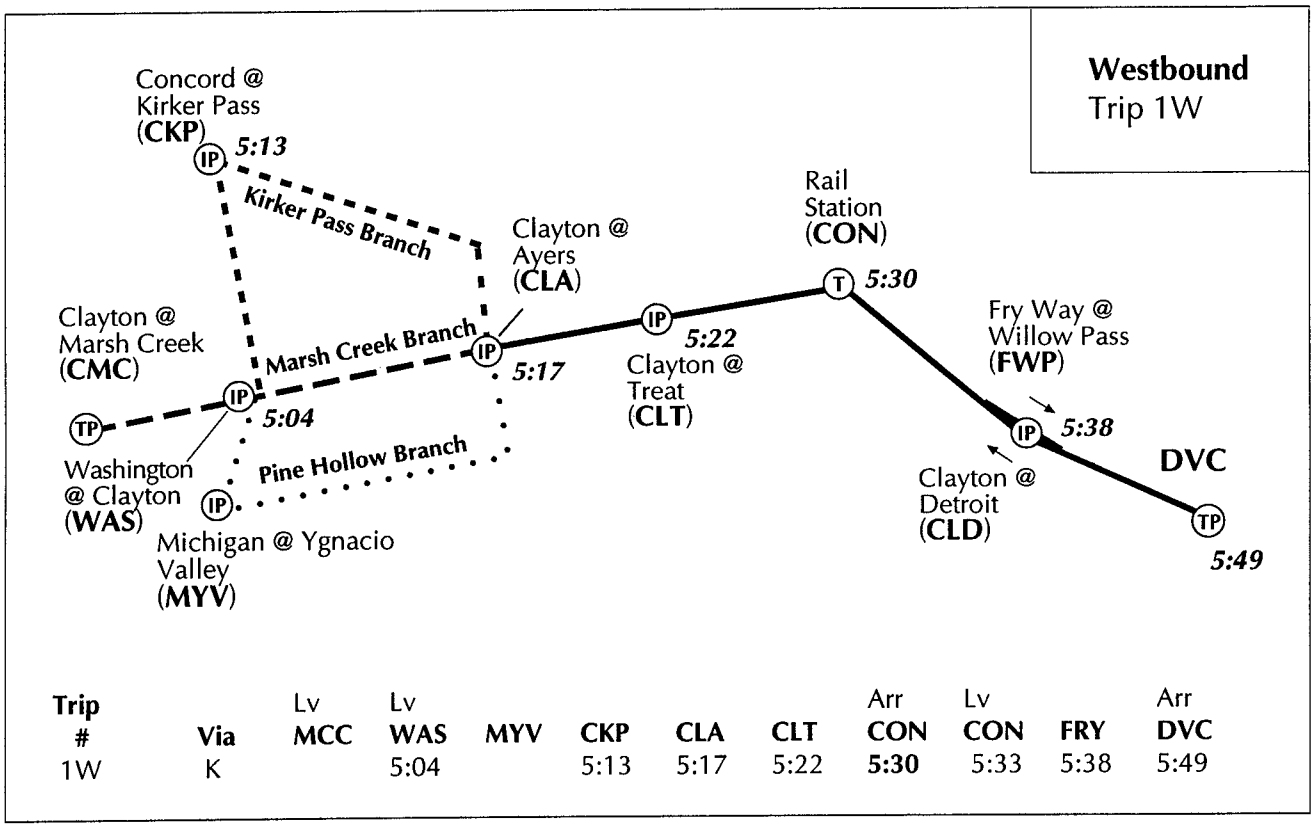
No layover or recovery time is provided at WAS. Since the vehicle will have only been in service for 17 minutes at a very early hour, the need for recovery time is minimal. Additionally, WAS is a residential intersection where idling vehicles during early morning hours could generate complaints from residents. Recovery time is alternatively stored at CON and DVC.

Note also that 1E follows the P branch and interlines to the K branch as trip 1W, as planned. The graphic on the following page illustrate the progression.



Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P				4:43	4:49	4:53		4:57	5:04	

The first eastbound trip 1E



Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49

The first westbound trip 1W

Given that trip 2W departs WAS in the westbound direction as a P trip at 5:21 a.m., the second eastbound trip (2E) is developed using the same pattern as used for trip 1E. Trip 2E departs CON at 4:59 a.m., operates eastbound as a K trip, and hooks to 2W at WAS at 5:21 a.m. Again, no recovery time is allowed.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
2E	K				4:59	5:05	5:09	5:13		5:21	

Trip #	*Via*	*Lv MCC*	*Lv WAS*	*MYV*	*CKP*	*CLA*	*CLT*	*Arr CON*	*Lv CON*	*FRY*	*Arr DVC*
2W	*P*		*5:21*	*5:28*		*5:32*	*5:37*	*5:45*	*5:48*	*5:53*	*6:04*

Although the route pattern dictates that trip 3E cover the M branch, it has been established that ridership demand on this segment does not require westbound service this early. In the interest of efficiency, the P branch will replace the M branch for this trip. Trip 3E hooks to 3W, which departs WAS at 5:31am.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
3E	P				5:05	5:11	5:15		5:19	5:27	

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
3W	K		5:31		5:40	5:45	5:51	**6:00**	6:03	6:09	6:21

Note that a 4-minute layover at WAS (from 5:27 a.m. until 5:31 a.m.) has been scheduled. This is necessary to fix the departure from CON at 5:05 a.m. to coordinate with the scheduled 5:00 a.m. train arrival, avoiding any negative perception of a "near miss" with the subsequent 5:10 a.m. train arrival. In this instance, the general interest in avoiding recovery time at the residential time point WAS is violated.

The next eastbound trip 4E provides coverage on the M branch and hooks to trip 4W, departing MCC at 5:43 a.m. One minute of recovery time is allowed at MCC.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
4E	M				5:21	5:27	5:31			5:34	5:42

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
4W	M	5:43	5:57			6:00	6:06	**6:15**	6:18	6:24	6:36

Trips 1E through 4E each will be operated by the first four vehicles pulled onto the route. All four vehicles are pulled on at CON, the preferred pull on point located nearest to the vehicle garage facility. Trips 5E and 6E hook to westbound trips 5W and 6W.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
5E	K				5:36	5:44	5:49	5:53		6:02	
6E	P				5:45	5:53	5:58		6:03	6:11	

Although pulling buses on and off Route 110 is most efficient at CON, it is common to use one or more secondary access points on a relatively long route. The secondary point on Route 110 is DVC. Ridership demand dictates that eastbound service from DVC begin at approximately 5:30 a.m. Since the first westbound trip (1W) is not scheduled to arrive at DVC until 5:49 a.m., another vehicle must pull onto the line at DVC to cover a 5:30 a.m. departure.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	Arr MYV	Arr WAS	Arr MCC
7E	M	5:30	5:40	**5:46**	**5:52**	6:00	6:05			6:09	6:17

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
7W	M	6:18	6:32			6:35	6:41	**6:50**	6:55	7:01	7:13

The new trip 7E will hook with westbound trip 7W, which departs MCC at 6:18 a.m. Assuming 1 minute of recovery time at MCC, 7E should arrive at MCC at 6:17 a.m. Referring back to the running time table, this requires a departure from DVC no later than 5:36 a.m. to reach MCC by 6:17 a.m. By scheduling the departure from DVC 6 minutes earlier, at exactly 5:30 a.m., a 6 minute window is created at CON to ensure schedule coordination between arriving buses and departing trains.

Since 1W completes its westbound run at DVC at 5:49 a.m., this vehicle may be used to cover an eastbound trip leaving DVC just before 6:00 a.m.

The eastbound trips constructed to this point are as follows:

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P				**4:43**	4:49	4:53		4:57	5:04	
2E	K				**4:59**	5:05	5:09	5:13		5:21	
3E	P				**5:05**	5:11	5:15		5:19	5:27	
4E	M				**5:21**	5:27	5:31			5:34	5:42
5E	K				**5:36**	5:44	5:49	5:53		6:02	
6E	P				**5:45**	5:53	5:58		6:03	6:11	
7E	M	5:30	5:40	5:46	5:52	6:00	6:05			6:09	6:17

Now that the pattern is well established, it is possible to complete the remaining eastbound t,rips which can be hooked to westbound trips 8W through 12W.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
8E	K	**5:44**	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
9E	P	**5:54**	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	

Note: Pull-out trips are shown in bold.

The schedule requires nine vehicles rather than ten as initially calculated on the basis of maximum cycle time. *Why wasn't a tenth vehicle required?*

Service was not required on the entire length of the route until 5:30 a.m., when eastbound service from DVC commenced. By not serving the segment west of CON in the early A.M., it was possible to extend the 10-minute headway into the A.M. peak without pulling out the tenth vehicle. This reduction would not have been possible if the 100-minute cycle time was required.

Also, recovery time was minimized during the first morning trips on the assumption that vehicles were not in revenue service long enough to fall behind schedule nor were operators behind the wheel long enough to require layover time.

Finally, the duration of the A.M. peak period was 70 minutes, which is less that the 100-minute cycle time.

C. Transition from A.M. peak to base time period

The transition from a 10-minute morning peak to the 20-minute base period is guided by three important objectives:

1) Achieving a smooth transition from 10 minutes on the trunk and 30 minutes on the branches to 20 minutes on the trunk and 60 minutes on the branches. In instances where the transition is to a longer headway (i.e., less frequent service) and/or where the change in headway is more than 5 minutes, it is generally considered good practice to spread out the transition over two, three or more consecutive trips.

2) Establishing a realignment of the schedule around a new controlling time point and direction. This is necessary because of the shift in the prevailing flow of Route 110 passenger traffic.

   As the morning peak transitions into the base period, the volume of rail feeder trips declines while the number of arriving rail passengers using the bus to reach the community college and shopping malls located at the western end of the route increases.

   Accordingly, the controlling time point changes from westbound bus arrivals at CON to westbound departures from CON.

3) Removing four of the nine peak buses from service as efficiently as possible, noting that the best place to pull a bus off the line is at CON.

Because westbound buses are arriving regularly to DVC during this period, no additional morning pull-outs will be required. The next four eastbound trips (13E through 16E) are subsequently constructed.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55

Trip #	Via	MCC	Lv WAS	Lv MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
4W	*M*	*5:43*	*5:57*			*6:00*	*6:06*	***6:15***	*6:18*	*6:24*	*6:36*
5W	*P*		*6:02*	*6:10*		*6:15*	*6:21*	***6:30***	*6:33*	*6:39*	*6:51*
6W	*K*		*6:11*		*6:20*	*6:25*	*6:31*	***6:40***	*6:43*	*6:49*	*7:01*
7W	*M*	*6:18*	*6:32*			*6:35*	*6:41*	***6:50***	*6:55*	*7:01*	*7:13*

- Eastbound trip 13E hooks to trip 4W, which arrives at DVC at 6:36a.m.
- Eastbound trip 14E hooks to trip 5W, which arrives at DVC at 6:51a.m.
- Eastbound trip 15E hooks to trip 6W, which arrives at DVC at 7:01a.m.
- Eastbound trip 16E hooks to trip 7W, which arrives at DVC at 7:13a.m.

Recalling that the last westbound trip constructed during the morning peak was 12W:

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03

The first westbound trip in the base period (13W) has the following three objectives:

1) Maintain the alternating branch pattern already established.

2) Generate an arrival time at CON that is somewhere between the 10-minute morning peak headway and the desired base headway of 20 minutes.

3) Establish a recognizable pattern of departure times from CON toward DVC that will carry through the base period.

Trip 13W below meets those conditions:

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23

Notes: Trip 13W follows the M pattern and allows 1 minute of recovery time (when hooked with 13E).
Arrival time at CON is 15 minutes later than the previous trip 12W. Departure time from CON occurs on the hour.

The next trip, 14W, follows the P pattern and maintains the headway at 15 minutes at the controlling time point Lv CON. It is hooked to eastbound trip 13E.

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
14W	P		7:39	7:47		7:52	7:58	8:07	*8:15*	8:21	8:34

Following these two consecutive westbound departures from CON at 8:00 a.m. and 8:15 a.m. (13W and 14W), the time is right to spread the next trip to the target base headway of 20 minutes. This requires a departure at 8:35 a.m. This means that one of the next two westbound trips must be truncated at CON and removed from service.

The next two westbound trips, 15W and 16W, follow the K and M branches, and arrive at CON at 8:24 a.m. and 8:32 a.m. respectively. Trip 16W is clearly the better of the two to maintain in service, since a 3-minute layover at CON allows an 8:35 a.m. departure exactly 20 minutes after trip 14W. This provides a good opportunity to establish the base 20-minute headway at 0:15, 0:35 and 0:55 minutes past the hour at Lv CON.

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
15W	K		7:55		8:04	8:09	8:15	8:24	**Out of service**		
16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54

Meanwhile, the last eastbound trip constructed during the A.M. peak was 16E:

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55

At the DVC end of the route, westbound buses will continue to arrive at-10 minute intervals until 8:03 a.m. (trip 12E). Trips 17E through 21E below are hooked to westbound arrivals 8W through 12W. One to two minutes of recovery time are allowed at DVC.

Entering the base period, running time decreases slightly and allows for more recovery time at DVC. As noted earlier, the extra running time is stored as additional recovery time at DVC in order to expand the "window of dwell time" during which transfers to other routes can be achieved.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	

Note that trip 18E deviates from the established rotating pattern of service to the branches. The second K trip is scheduled instead of adding a school extra to serve the morning bell of the local high school located near the MYV time point.

Three of the next westbound trips must pull out of service. Because the desired effect is to cut the 10-minute headway in half, it makes sense that every other bus should be removed from service until the five buses needed to operate the desired base period headway remain on the line.

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
17W	P		8:09	8:17		8:23	8:29	8:38	**Out of service**		
18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	K		8:29		8:38	8:42	8:47	8:56	**Out of service**		
20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	P		9:00	9:07		9:11	9:16	9:25	**Out of service**		

Recap: Shown below are the 12 westbound trips arriving at CON from 7:30 a.m. until 9:38 a.m. During this period, the schedule transitions from an even 10-minute headway between arrivals at CON (until 7:40 a.m.) to 15 minutes and then to 20 minutes between departures from CON.

Four of nine buses operating in morning peak service are removed from service, leaving five base blocks to carry through the base time period.

Route 110 - Westbound (recap)
Morning Peak to Base Period Transition

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
15W	K		7:55		8:04	8:09	8:15	8:24	**Out of service**		
16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
17W	P		8:09	8:17		8:23	8:29	8:38	**Out of service**		
18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	K		8:29		8:38	8:42	8:47	8:56	**Out of service**		
20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	P		9:00	9:07		9:11	9:16	9:25	**Out of service**		
22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59

Note that the departure time of trips 20W and 22W from CON are not exactly 20 minutes apart. These variations are made deliberately in order to create minimum 15-minute mid-run layovers that are required by labor agreement for full-time runs.

The figure below shows the 13 eastbound trips that comprise the morning peak to base period transition. Uneven headways result from the attention given to westbound arrivals and departures to and from the train station CON.

Route 110 - Eastbound (recap)
Morning Peak to Base Transition

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	

D. Base period – pulse/timed transfer windows

During base period, both CON and DVC serve as pulse transfer points for Route 110 and other routes operating in the area. Bus schedules are designed to meet at the rail station once an hour.

A timed transfer window of approximately 10 minutes – from :55 minutes past the hour until :05 minutes past the hour – is designed around train arrivals and departures. All bus/rail connections are timed, and all possible bus/bus connections are timed as well. Ridership and passenger transfer data could be used to identify particular bus/bus connections that should be supported in the schedules.

The base period service design of Route 110 calls for a 20-minute base period headway. This means that every third arrival and departure at CON should fall within the timed transfer window. Every third bus in both directions should be timed to arrive at the top of the hour.

The base period schedule pattern is established by trip 22W, which arrives at CON 13 minutes after 21W, at 9:38 a.m. Two minutes of dwell time are allowed to produce a departure at :40 minutes past the hour, allowing the next trip (23W) to depart at the top of the hour.

This sets the pattern for the next 15 westbound trips that operate until after 2:00 p.m. when a transition to the school period becomes necessary. Base period westbound trips arrive at :18, :38 and :58 minutes past the hour and depart at :20, :40 and :00 minutes after the hour.

Route 110 - Westbound
Base Period Trips

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57
29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58

Base period eastbound trips are shown below. Arrivals at CON occur at :03, :23 and :43 minutes past the hour (1 minute earlier after 10:00 a.m.). Two to three minutes of dwell time are allowed, resulting in departures at :05, :25 and :45 minutes past the hour.

Route 110 - Eastbound
Base Period Trips

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
27E	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29

Note that the timed trips follow the M pattern in both directions. This practice generates very competitive transit travel times for passengers making longer bus/rail trips. The M branch is selected because it generates the highest passenger volumes of the three branches during the base period. Offering the benefit to different branches in the morning and evening peak periods would tend to reduce the attractiveness of transit travel to a larger number of passengers.

E. School extras

A school extra is a trip (or series of trips) added to accommodate the impact of large numbers of students arriving to or departing from a school located along a regular route. School extras typically operate on school days only and often consist of a partial trip or trips as necessary to accommodate actual demand. While school extras may be added in the morning or afternoon, they are more commonly needed at the afternoon bell. School extras are available to students and to the general public just as any other trip.

Looking back to the morning peak schedule of Route 110, extra capacity was provided without the need for any extra vehicles. This was possible because the morning school bell occurred during the peak period when the trunk headway was 10 minutes. By interrupting the alternating branch pattern and running two consecutive trips via the K branch, it was possible to bring two regular route vehicles to the school within 10 minutes of each other.

Unfortunately, additional school capacity for the afternoon bell cannot be accomplished in the same manner. The school dismissal time occurs 90 minutes before the 10-minute afternoon peak headway is needed. The 20-minute interval between Route 110 buses during the base period makes it impractical to rely solely on the buses in regular service. Students are unlikely to wait 20 minutes for the second bus and accelerating the arrival time would create an unacceptable gap in service just before the transition to the peak service is initiated. Therefore, an extra trip must be added.

School Period Trips:

Route 110 - Westbound

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
39W	**K**		**2:44S**		**2:51S**						
40W	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05

Route 110 - Eastbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36

Trips 38W, 39W and 40W all pass the local high school, which is located near the time point WAS (Washington @ Clayton). Afternoon dismissal occurs at 2:35 p.m.

Trip 38W is a regular trip that passes the school 5 minutes after bell time. Note that the same running time is allowed as for other westbound M branch trips, even though it can be assumed that this trip may run behind schedule on school days due to heavy passenger loadings. This is done so that the trip will not run early on non-school days when passenger volumes are likely to be much lower. To enable the operator to get back on schedule as soon as the impact of the student load is distributed, additional recovery time at CON is allowed before continuing westbound to DVC.

Trip 39W is the school extra. It enters revenue service at the school 4 minutes following the scheduled departure of trip 38W and 9 minutes after the dismissal bell. Note that this trip follows the K branch and departs the school in a northbound direction. It will remain on route until all passengers have alighted.

Trip 40W is a regular route trip that passes the school 19 minutes after bell time. It operates southbound from the school to the area served by the P branch. Given that the wait time will discourage some passengers from using the bus, it could be assumed that the number of potential riders on this branch is lower than on the others.

Trip 41W passes the high school 37 minutes after bell time, serving as a "clean-up" trip for those passengers who may have missed trip 39W.

In this example, only one school extra has been added. However, it is quite common to operate several school extras or trippers as necessary to accommodate demand. The use of higher capacity (i.e., articulated) vehicles could be considered to respond to the impact of school demand without adding additional vehicles to the route.

F. Transition from base/school to the P.M. peak

The transition from the base/school period to the P.M. peak is influenced by many of the same considerations that were encountered earlier in the service day:

- Reduce headway from 20 to 10 minutes.
- Bring additional buses from the vehicle garage facility into revenue service at the nearest time point (CON) whenever possible.
- Reset the controlling time point as appropriate to address the bus/rail scheduling connections.

As before, the headway should decrease smoothly over several consecutive trips. When to restore the peak period service level varies from route to route, but is generally determined by the volume of passenger traffic and service productivity objectives.

Route 110 covers suburban communities with access to a commuter rail line. Assuming one-way train trips of approximately 1 hour, many commuters do not reach CON until after 6:00 p.m. Therefore, the P.M. peak 10-minute headway is maintained until at least 6:30 p.m. or 6:45 p.m.

Local workers and students are likely to use bus service between 4:30 p.m. and 5:15 p.m. This means that the P.M. peak period will be longer than the A.M. peak – over 2 hours compared to just 70 minutes in the A.M.

Nine vehicles are required to generate a -0 minute trunk headway in the A.M. peak. Based on cycle time alone, 10 vehicles should have been required. However, one less vehicle was needed because the duration of the A.M. peak period (90 minutes) is shorter than the cycle time (100 minutes) of the A.M. peak period and because a number of vehicles were pulled on at CON without making full round trips.

The duration of the P.M. peak (120 minutes) is greater than (or equal to) the cycle time (110 minutes). Therefore, it can be projected that all 11 vehicles estimated to be needed for P.M. peak revenue service will be required in order to generate the desired 10-minute trunk headway on Route 110.

Five vehicles have been operating during the base period, and a sixth was added during the school period. A second objective of the scheduling transition into the P.M. peak is then to integrate five additional vehicles to the line as efficiently as possible. Vehicles pull onto the line in a similar manner as they were pulled off near the end of the morning peak.

A third objective during the transition into the afternoon peak is to reset the controlling time point. There are two significant passenger flows during this time period:

1) Rail commuters returning home to the residential neighborhoods served by the three route branches at the east end of the route; and

2) Students, shoppers and retail district employees returning to the rail station from the west end of the route.

To accommodate these passenger flows, the afternoon peak schedule will be developed around:

- Eastbound arrivals at CON,
- Eastbound departures from CON, and
- Westbound departures from CON.

While bus departures occur every 10 minutes, evening train arrivals occur at 7.5-minute intervals. Because the bus and rail headways are not even multiples of one another, they are not compatible for timed transfers. As with the morning peak, this is not a significant problem as both are relatively frequent and transfer wait times are consequently low.

The optimal strategy for intermodal transfers is to provide even intervals between bus departures and arrivals at the controlling time point, except as necessary to steer away from "near misses" in rail/bus transfers as perceived by customers.

The transition from base/school to P.M. peak begins with trip 45E in the eastbound direction. Trips 42E through 44E maintain the 20-minute base/school period headway, with departures from DVC evenly spaced at :00, :20 and :40 minutes past the hour and with arrivals at CON at :20, :40 and :00.

Route 110 - Eastbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
45E	K		**Into service**		4:12	4:22	4:29	4:34		4:44	
46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14

Route 110 - Westbound

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22

Trip 37W hooks to eastbound trip 42E, allowing 2 minutes of recovery time (2:58 p.m. until 3:00 p.m.) at DVC. Since the next westbound arrival at DVC does not occur until 3:22 p.m. (trip 38W), a vehicle must be added to cover trip 43E beginning at 3:20 p.m. This could be hooked to trip 39W on school days.

The addition of the 3:20 p.m. departure provides a drop-back through which additional layover can be provided between trips at DVC. This provides an opportunity for mid-run breaks of at least 15 minutes if required by contract. For example, if applied to Route 110, trip 38W could hook to eastbound trip 44E, allowing 18 minutes at DVC. This would consist of 3 minutes of recovery time (3:22 p.m. until 3:25 p.m.) and 15 minutes of layover (3:25 p.m. until 3:40 p.m.) for a total of 18 minutes.

The second afternoon pull-out enters revenue service at CON at 4:12 p.m. and makes trip 45E. Trip 40W hooks to 46E, allowing 12 minutes of recovery time (3:43 p.m. until 3:55 p.m.) at DVC. These trips absorb the service frequency transition from 20 to 10 minutes.

G. P.M. peak service

The 10-minute eastbound headway is established by trip 47E and continues through trip 58E with evenly spaced departures from CON. Note the two additional buses that enter revenue service to make trips 48E and 50E from CON. The result is that the 10-minute headway of departures from DVC does not begin until 5:15 p.m.

P.M. Peak Trips

Route 110 - Eastbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
48E	K			**Into service**	4:50	5:00	5:07	5:12		5:22	
49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
50E	M			**Into service**	5:10	5:20	5:27			5:30	5:44
51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
52E	P			**Into service**	5:30	5:40	5:47		5:52	6:00	
53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
56E	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	

Since eastbound is the prevailing direction of passenger traffic during the P.M. peak, the westbound schedule simply accommodates the eastbound trips. The -0 minute interval between departures from CON is established by trip 45W at 5:05 p.m., and subsequent trips are evenly spaced. The schedule pattern will be maintained for 14 consecutive trips, until 7:25 p.m. The eleventh and final bus of the P.M. peak enters revenue service at 5:35 p.m. at CON and operates trip 48W.

Route 110 - Westbound

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
48W	--						**Into service**		5:35	5:41	5:54
49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24
58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41

H. Evening and night service

The level of service requirement drops substantially after the end of the P.M. peak. Prevailing traffic flows remain unchanged, however, so that the controlling time point for eastbound departures continues to be CON. Therefore, the major objective of the transition is to remove buses from service efficiently while preserving a recognizable headway and service pattern.

The eastbound trips are developed around the controlling time point CON. The 10-minute peak headway spreads to 15 minutes between eastbound departures after 6:30 p.m. (trips 59E through 61E), to 20 minutes after 7:30 p.m. (trips 62E through 65E), and 30 minutes after 8:30 p.m. until the end of the service day (trips 66E through 69E).

Evening and Night Period Service

Route 110 - Eastbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
59E	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
60E	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
61E	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
62E	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
65E	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
66E	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
67E	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
68E	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
69E	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

Route 110 westbound service operates until 11:18 p.m. Because the westbound direction has lower passenger traffic, the decision is made to remove buses from revenue service after arriving at CON. This will inconvenience fewer passengers than truncated eastbound trips.

The basic approach is to remove every other bus arriving at CON after 7:30 p.m. Trips 60W, 62W, 64W and 67W pull to the garage.

Notice the headway transition of arrivals at the western terminal DVC. The-20 minute interval between trips 61W and 63W gives way to 30 minutes between trips 63W, 65W and 66W, and 40 minutes between 66W and 67W.

Evening and Night Period Service (con't)

Route 110 - Westbound

Trip #	Lv Via	Lv MCC	WAS	MYV	CKP	CLA	Arr CLT	Lv CON	Arr CON	FRY	DVC
60W	K		7:07		7:15	7:19	7:24	7:32	**Out of service**		
61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06
62W	P		7:28	7:35		7:39	7:44	7:52	**Out of service**		
63W	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26
64W	M	8:00	8:08			8:11	8:16	8:24	**Out of service**		
65W	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56
66W	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26
67W	M	9:00	9:08			9:11	9:16	9:24	**Out of service**		
68W	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06
69W	K		9:53		10:01	10:05	10:10	10:18			
70W	P		10:24	10:31		10:35	10:40	10:48			
71W	K		10:53		11:01	11:05	11:10	11:18			

All trips for Route 110 have been generated and a completed master schedule is shown at the end of this section. The next step involves blocking the trips into vehicle assignments. The blocking process, using Route 110 and Revised Route 32 as models, is covered in Chapter 3.

XII. Rail Scheduling

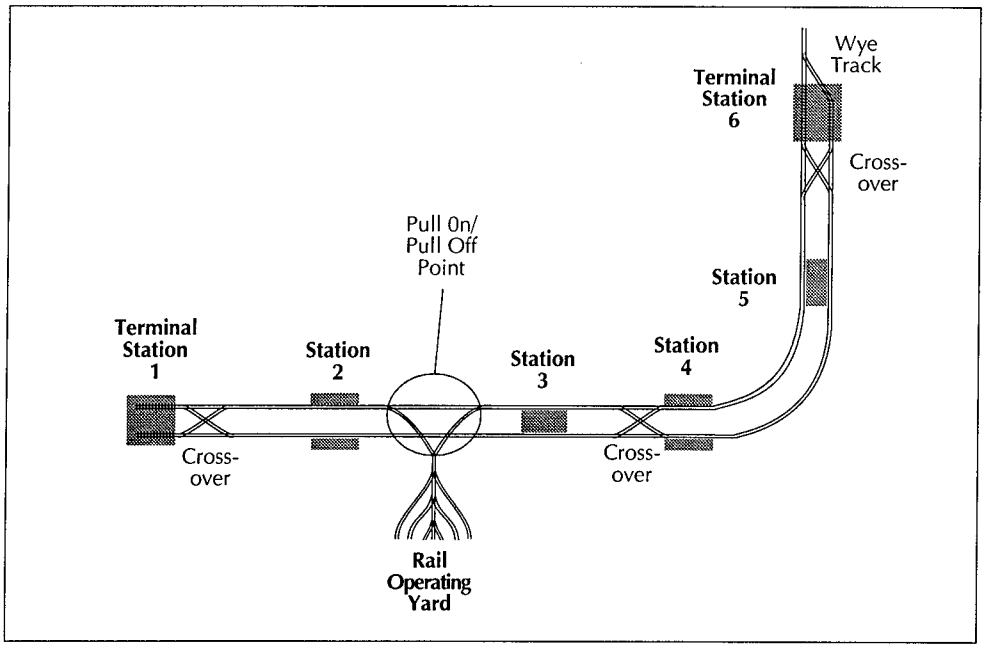
Generally, most scheduling principles apply to both rail and bus. However, schedulers face many unique issues and constraints emanating from the lack of flexibility that operating on fixed track presents. The impact of these issues on scheduling efficiency depends significantly on the physical layout of the rail network and the type of train control system used. Representative examples of those issues are presented in this section.

A. Example rail system layout

The simplest and most common layout of rail facilities is "double track." This configuration consists of two tracks lying side by side in the railbed. Double track provides for the unobstructed flow of trains operating in opposite directions. Stations located along double track segments are either "outside platform" or "center platform." Each station is generally a published time point.

"Crossover" tracks are often located near the terminating stations on the line. These crossovers are of concern to the scheduler because trains in both directions must use them in order to reverse direction at the end of the line. The "yard track" is a connecting spur between the main line and the rail maintenance and/or storage yard.

A simplified double track line serving two terminal stations and four intermediate stations is shown on the next page. Trains pull into and out of service from a yard line between Stations 2 and 3. The crossover between stations 3 and 4 is primarily for emergency use only.



Example layout of a simplified rail line with double track operation

B. Special considerations for rail

The limited flexibility of operating on fixed rail usually results in additional constraints for the scheduler, generally in addressing five typical areas:

1) Minimum spacing between trains
2) Pulling trains into and out of revenue service
3) Passing trains
4) Single track operations
5) Merging tracks and terminal point scheduling

1) Minimum spacing between trains

Spacing is a critical concern. Most systems require, as a matter of operating policy, a minimum time and/or distance between trains, both for safety considerations and to ensure a smooth flow of service. The specific operating policy for minimum spacing varies between systems, but is typically between 1 and 3 minutes. Factors that influence spacing include train volumes, length of train sets, safety, history and the sophistication of the train control system.

2) Pulling trains into and out of revenue service

The techniques for moving trains into and out of revenue service are similar to those used for bus scheduling. However, it is extremely important that trains entering and leaving the main track be coordinated with trains operating in revenue service.

The following table illustrates how trains would pull onto the example rail line given the following operating characteristics.

Cycle Time	60 Minutes
Frequency	15 Minutes, both directions
Number of Trains	4
First Pullout no earlier than	4:30a.m.

Eastbound (A.M.)

	Station	**1**	**2**	**3**	**4**	**5**	**6**
Train#	Pullout						
101	**4:33**			4:35	4:41	4:46	4:51
103	**4:48**			4:50	4:56	5:01	5:06
102		4:55	5:01	5:05	5:11	5:16	5:21
104		5:10	5:06	5:10	5:26	5:31	5:36
101		5:25	5:31	5:35	5:41	5:46	5:51
103		5:40	5:46	5:50	5:56	6:01	6:06
102		5:55					
104		6:10					

Example schedule demonstrating A.M. pull-outs eastbound

Westbound (A.M.)

	Station	**6**	**5**	**4**	**3**	**2**	**1**
Train#	Pullout						
102	**4:44**					4:46	4:50
104	**4:59**					5:01	5:05
101		4:55	5:01	5:06	5:12	5:16	5:20
103		5:10	5:16	5:21	5:27	5:31	5:35
102		5:25	5:31	5:36	5:42	5:46	5:50
104		5:40					
101		5:55					
103		6:10					

Example schedule demonstrating A.M. pullouts westbound

Trains leave the yard at 4:33, 4:44, 4:48 and 4:59 a.m. respectively. A deadhead time of 2 minutes is allowed to either Station 3 for eastbound trains or Station 2 for westbound trains.

3) Passing trains

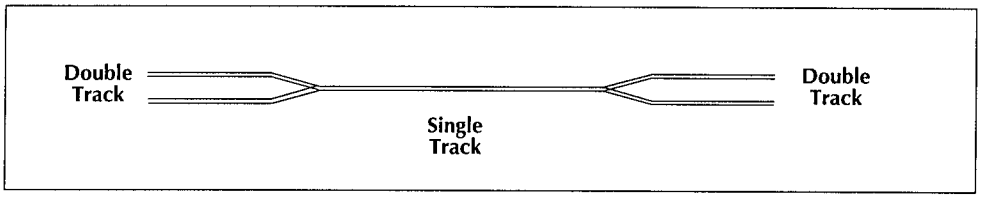
Buses operating on public streets are generally able to pass other buses as dictated by service requirements. However, rail operations do not share this flexibility. Trains operating in scheduled service on a double track configuration generally cannot pass other trains unless a parallel express track is available.

In some instances, trains operating in revenue service can pass an out-of-service train when a side track is available to momentarily store the out-of-service train or when a crossover track is available to divert the out-of-service train from the main track.

4) Single track operations

Train movements are highly constrained on segments where only one track is available for trains travelling in both directions. Single track operation creates a bottleneck that requires special consideration by the scheduler. The severity of the bottleneck is a function of the length of the one-way track segment, the frequency of trains and the reduced operating speeds that are typically required for single track operation.

For lower frequency operations such as commuter rail, it is possible that single track operations may prove adequate. However, in Heavy Rail Transit (HRT) or Light Rail Transit (LRT) systems with a higher volume of trains, single track operations are limited to short segments. Safety concerns dictate that train operating speeds be reduced on these sections and minimum spacing intervals be strictly enforced.



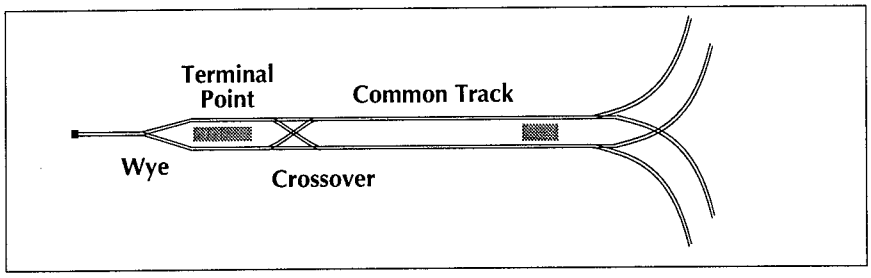
Example of a single track segment on a double track layout

In the example above, only one train at a time can enter and travel through a single track segment. The time a train requires to travel the single track will affect the level of service that can be provided. For example, a 3-minute requirement on the single track will dictate a minimum 7- to 10-minute service frequency, depending on minimum spacing requirements.

5) Merging tracks and terminal point scheduling

A number of unique scheduling issues arise when two or more rail lines merge onto a single alignment or "common track." Most important are safety considerations. For the passenger, common tracks can sometimes be confusing when multiple routes serve a common stop.

Perhaps the most significant potential bottleneck in the common track scenario is the terminal point. Terminal rail stations are typically equipped with crossover tracks that allow trains to enter, layover and depart the station without blocking one another. The crossover may be located either forward of the station on the active line track or beyond the station on a "Wye" or spur track. The configuration of the crossover track affects the number of trains that can be accommodated at the terminal point.



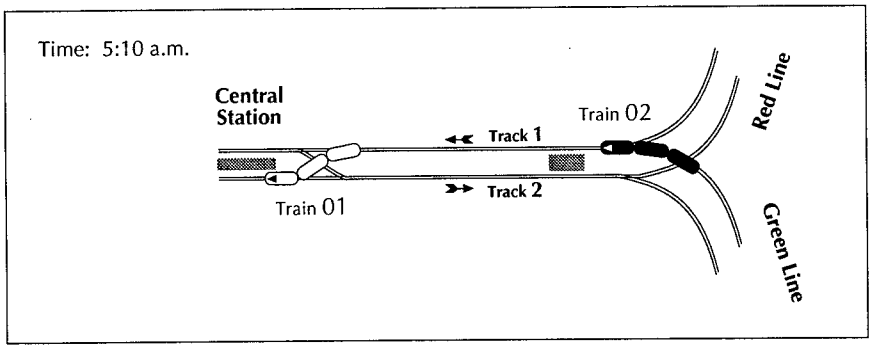
Typical rail terminal point crossover options involving common track

Example: Crossing Over Two Lines Operating the Same Frequency at a Terminal Point

In the following illustration two rail lines, the Red Line and the Green Line terminate at Central Station. Both lines share a common track for both the Central Station and one other station. The scheduler must determine the desired pattern and spacing between trips operating on the common track while maintaining a minimum policy spacing between trains of at least 2 minutes. Central Station consists of a center platform with a track on each side and a forward crossover ahead of the platform. The scheduler intends that all trains inbound to Central Station utilize Track 1, while outbound trains utilize Track 2.

The Red and Green Lines are intended to operate 15-minute headways during the day with a 10-minute layover at Central Station. A straight forward option would be to introduce alternating Red and Green Line trains onto the common track. Under optimal conditions, each would enter the common track at 7- and 8-minute intervals.

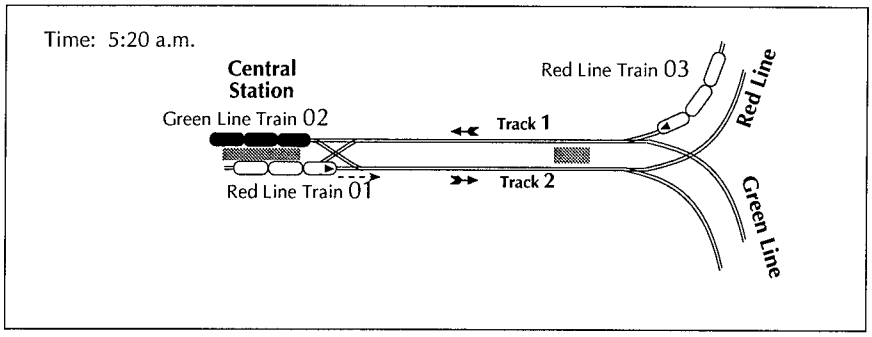
Red Line train 01 is scheduled to arrive at Central Station at 5:10 a.m. The scheduler opts to have this train cross over to Track 2 before entering Central Station for a 10-minute layover. Green Line train 02 is due to arrive at Central Station at 5:17 a.m.



Inbound Track 1 Red Line train 01 arrives at central station at 5:10 a.m.

At 5:17 a.m., train 01 will still be laying over at Central Station occupying Track 2. The scheduler determines that inbound Green Line train 02 can arrive at Central Station on Track 1 and remain on Track 1 for its 10-minute layover.

At 5:20 a.m., Red Line train 01 is ready to begin an outbound trip. Since it is already on Track 2, it will proceed straight ahead. The next Red Line train 03, maintaining a 15 minute headway, is due to arrive at Central Station at 5:25 a.m.



Outbound Red Line train 01 proceeds directly on track 1.

Since Track 2 at Central Station is now open for layover, inbound Red Line train 03 will move from Track 1 to Track 2 at the crossover and layover on Track 2 (similar to Red Line train 01).

A pattern has now been established. Red Line trains arrive on Track 1 and crossover to Track 2 before pulling into Central station. Red Lines depart the station directly on Track 2. Green Line trains also inbound on Track 1. However, they inbound directly into the station on Track 1, take a layover, then cross over to Track 2 for outbound departure.

An example Central Station train arrival and departure schedule is shown below. A minimum of 2 minutes of train spacing is maintained and the predictable pattern minimizes passenger confusion. However, the scheduler will likely have to coordinate train arrivals and departures at outlying stations and switches, support timed transfers, and accommodate service level adjustments over the course of the day. These issues may cause the predictable pattern to vanish quickly .

Where different line headways, more frequent service and spacing increases are considered, the scheduler often finds that the use of sophisticated automatic train control (ATC) systems and higher capacity crossover and Wye tracks are needed to develop safe and effective schedules.

Central Station
Red and Green Line Arrivals and Departures

Line	Train	Arr Hdwy	Arr Time	Layover Track	Layover Minutes	Depart Time	Depart Hdwy
Red	01		5:10	2	:10	5:20	
Green	02		5:17	1	:10	5:27	
Red	03	15	5:25	2	:10	5:35	15
Green	04	15	5:32	1	:10	5:42	15
Red	05	15	5:40	2	:10	5:50	15
Green	06	15	5:47	1	:10	5:57	15
Red	07	15	5:55	2	:10	6:05	15
Green	08	15	6:02	1	:10	6:12	15

Route 110 /WESTbound

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49
2W	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04
3W	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21
4W	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36
5W	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51
6W	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01
7W	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13
8W	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23
9W	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33
10W	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43
11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
15W	K		7:55		8:04	8:09	8:15	8:24	Out of service		
16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
17W	P		8:09	8:17		8:23	8:29	8:38	Out of service		
18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	K		8:29		8:38	8:42	8:47	8:56	Out of service		
20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	P		9:00	9:07		9:11	9:16	9:25	Out of service		
22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57
29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
39W	K		2:44S		2:51S	(School Days Only)					
40W	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
48W	--							Into service	5:35	5:41	5:54
49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24
58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41
60W	K		7:07		7:15	7:19	7:24	7:32	Out of service		
61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06
62W	P		7:28	7:35		7:39	7:44	7:52	Out of service		
63W	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26
64W	M	8:00	8:08			8:11	8:16	8:24	Out of service		
65W	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56
66W	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26
67W	M	9:00	9:08			9:11	9:16	9:24			
68W	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06
69W	K		9:53		10:01	10:05	10:10	10:18	Out of service		
70W	P		10:24	10:31		10:35	10:40	10:48	Out of service		
71W	K		10:53		11:01	11:05	11:10	11:18	Out of service		

Route 110 /EASTbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P			Into service	4:43	4:49	4:53		4:57	5:04	
2E	K			Into service	4:59	5:05	5:09	5:13		5:21	
3E	P			Into service	5:05	5:11	5:15		5:19	5:27	
4E	M			Into service	5:21	5:27	5:31			5:34	5:42
5E	K			Into service	5:36	5:44	5:49	5:53		6:02	
6E	P			Into service	5:45	5:53	5:58		6:03	6:11	
7E	M	5:30	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8E	K	5:44	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
9E	P	5:54	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
27E	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
45E	K			Into service	4:12	4:22	4:29	4:34		4:44	
46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
48E	K			Into service	4:50	5:00	5:07	5:12		5:22	
49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
50E	M			Into service	5:10	5:20	5:27			5:30	5:44
51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
52E	P			Into service	5:30	5:40	5:47		5:52	6:00	
53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
56E	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	
59E	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
60E	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
61E	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
62E	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
65E	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
66E	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
67E	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
68E	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
69E	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

CHAPTER 2: EXERCISES

- Prepare a Route 110 master schedule (both directions) for Saturdays. Use the following assumptions:

  - Hours of operation: Begin service at approximately 7:00 a.m. and end service at approximately 10:00 p.m.

  - Headways: Operate a 30-minute trunk headway until approximately 7:00 p.m. and a 60-minute headway thereafter. Operate alternating service on the "K" and "P" branches only. Do not serve the "M" branch.

  - Running Times: Use weekday base period running times in both directions until 3:00 p.m. and after 6:00 p.m. Use peak weekday running times between 3:00 p.m. and 6:00 p.m.

  - Controlling Time Points: Coordinate buses with train arrivals and departures at CON to the maximum extent possible. Assume that eastbound trains arrive at :02, :17, :32 and :47 and that westbound trains depart at :08, :23, :38 and :53 after the hour.

CHAPTER 2: EXERCISE ANSWER SHEET

Master Schedule - Route 110 Saturday Service

The following Master Schedule for Route 110 Saturday service presents one possible answer. It satisfies the frequency, branching and running time specifications. It also starts in each direction at approximately 7:00 a.m. and ends in each direction at approximately 10:00 p.m.

The actual start and end times were controlled by the desire to meet the train schedule as often as possible. The Saturday layovers at CON are considerably longer than weekday layovers when the service better matches the frequency of the trains. A train connection matrix is shown below.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
-	-	-	-	-	-	-	-	-	-	-	
1E	P		Into Service		6:55	7:03	7:08		7:12	7:19	
2E	K		Into Service		7:25	7:33	7:38	7:42		7:50	
3E	P		Into Service		7:55	8:03	8:08		8:12	8:19	
4E	K	7:58	8:09	8:15	8:25	8:33	8:38	8:42		8:50	
5E	P	8:28	8:39	8:45	8:55	9:03	9:08		9:12	9:19	
6E	K	8:58	9:09	9:15	9:25	9:33	9:38	9:42		9:50	
7E	P	9:28	9:39	9:45	9:55	10:03	10:08		10:12	10:19	
8E	K	9:58	10:09	10:15	10:25	10:33	10:38	10:42		10:50	
9E	P	10:28	10:39	10:45	10:55	11:03	11:08		11:12	11:19	
10E	K	10:58	11:09	11:15	11:25	11:33	11:38	11:42		11:50	
11E	P	11:28	11:39	11:45	11:55	12:03	12:08		12:12	12:19	
12E	K	11:58	12:09	12:15	12:25	12:33	12:38	12:42		12:50	
13E	P	12:28	12:39	12:45	12:55	13:03	13:08		13:12	13:19	
14E	K	12:58	13:09	13:15	13:25	13:33	13:38	13:42		13:50	
15E	P	13:28	13:39	13:45	13:55	14:03	14:08		14:12	14:19	
16E	K	13:58	14:09	14:15	14:25	14:33	14:38	14:42		14:50	
17E	P	14:28	14:39	14:45	14:53	15:03	15:10		15:15	15:23	
18E	K	14:57	15:08	15:16	15:23	15:33	15:40	15:45		15:55	
19E	P	15:25	15:38	15:46	15:53	16:03	16:10		16:15	16:23	
20E	K	15:55	16:08	16:16	16:23	16:33	16:40	16:45		16:55	
21E	P	16:25	16:38	16:46	16:54	17:04	17:11		17:16	17:24	
22E	K	16:55	17:08	17:16	17:24	17:34	17:41	17:46		17:56	
23E	P	17:25	17:38	17:46	17:54	18:04	18:11		18:16	18:24	
24E	K	17:58	18:09	18:15	18:25	18:33	18:38	18:42		18:50	
25E	P	18:28	18:39	18:45	18:55	19:03	19:08		19:12	19:19	
26E	K	18:58	19:09	19:15	19:25	19:33	19:38	19:42		19:50	
27E	P	19:58	20:09	20:15	20:25	20:33	20:38		20:42	20:49	
28E	K	20:58	21:09	21:15	21:25	21:33	21:38	21:42		21:50	
29E	P	21:58	22:09	22:15	-	-	-	-	-	-	

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	P		6:54	7:01		7:05	7:10	7:19	7:34	7:40	7:53
2W	K		7:24		7:33	7:37	7:42	7:51	8:04	8:10	8:23
3W	P		7:54	8:01		8:05	8:10	8:19	8:34	8:40	8:53
4W	K		8:24		8:33	8:37	8:42	8:51	9:04	9:10	9:23
5W	P		8:54	9:01		9:05	9:10	9:19	9:34	9:40	9:53
6W	K		9:24		9:33	9:37	9:42	9:51	10:04	10:10	10:23
7W	P		9:54	10:01		10:05	10:10	10:19	10:34	10:40	10:53
8W	K		10:24		10:33	10:37	10:42	10:51	11:04	11:10	11:23
9W	P		10:54	11:01		11:05	11:10	11:19	11:34	11:40	11:53
10W	K		11:24		11:33	11:37	11:42	11:51	12:04	12:10	12:23
11W	P		11:54	12:01		12:05	12:10	12:19	12:34	12:40	12:53
12W	K		12:24		12:33	12:37	12:42	12:51	13:04	13:10	13:23
13W	P		12:54	13:01		13:05	13:10	13:19	13:34	13:40	13:53
14W	K		13:24		13:33	13:37	13:42	13:51	14:04	14:10	14:23
15W	P		13:54	14:01		14:05	14:10	14:19	14:34	14:40	14:53
16W	K		14:24		14:33	14:37	14:42	14:51	15:04	15:10	15:23
17W	P		14:54	15:01		15:05	15:11	15:21	15:34	15:40	15:53
18W	K		15:23		15:32	15:37	15:43	15:53	16:04	16:10	16:23
19W	P		15:55	16:02		16:06	16:12	16:22	16:34	16:40	16:53
20W	K		16:23		16:32	16:37	16:43	16:53	17:04	17:10	17:23
21W	P		16:55	17:02		17:06	17:12	17:22	17:34	17:40	17:53
22W	K		17:24		17:33	17:38	17:44	17:52	18:04	18:10	18:23
23W	P		17:56	18:03		18:07	18:12	18:21	18:34	18:40	18:53
24W	K		18:24		18:33	18:37	18:42	18:51	19:04	19:10	19:23
25W	P		18:54	19:01		19:05	19:10	19:19	19:34	19:40	19:53
-	-	-	-	-	-	-	-	-	-	-	-
26W	K		19:54		20:03	20:07	20:12	20:21	20:34	20:40	20:53
27W	P		20:54	21:01		21:05	21:10	21:19	21:34	21:40	21:53
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

BUS		TRAIN Eastbound	TRAIN Westbound
Eastbound Route 110 arrival at CON	:15 - :16	:17 Lv	:23 Lv
	:45 - :46	:47 Lv	:53 Lv
Eastbound Route 110 departure from CON	:23 - :25	:17 Arr	:23 Arr
	:53 - :55	:47 Arr	:53 Arr
Westbound Route 110 arrival at CON	:19 - :23	:32 Lv	:23 Lv
	:51 - :54	:02 Lv	:53 Lv
Westbound Route 110 departure from CON	:04	:02 Arr	:53 Arr
	:34	:32 Arr	:23 Arr

Notes:

CHAPTER 3

BLOCKING

Advanced Section

I. Introduction

In urban settings, routes are seldom designed to offer the same headway and running time throughout the day. Most urban routes are designed with complexities that include multiple terminals, variable running times, headway variations between peak and midday service, "extra" trips for school service, mid-route recovery at a timed transfer or rail station location and route interlining. Route 110, containing many of these complexities, will be blocked in this chapter.

The basic skills involved in blocking a more complex route are the same as for a simple route. Trips are "hooked" or linked together into vehicle assignments based on the requirement for layover and recovery time and the goal of minimizing the number of required vehicles. It is necessary to keep in mind a few basic rules when blocking these more complex routes:

II. Basic Blocking Rules

- **Route variations are generally interlined only at common terminals.** For example, departing Route 110 trips from the common terminal DVC may serve any of the three route variations. Route 110 has two principal pull-on and pull-off terminals, one at DVC and one at the rail station (CON). Most trips serve both terminals, but peak trips may begin or end at the rail station. There are two "outer" terminals, one at Washington and Clayton (WAS) and one at Marsh Creek Circle (MCC). Trips that arrive at a particular terminal would leave from that terminal in revenue service, rather than deadheading from one terminal to another.

- **For a route with multiple terminals, it is desirable to make space for more than one terminal on the blocking sheet.** A recommended format follows the Route 110 master schedule shown in the following pages.

- **Some blocks are likely to operate only during peak service,** while other blocks will provide service throughout the day. When initially linking trips into a block, trips are hooked until there is either too little recovery time to comply with labor contract requirements or too much recovery time to be economically viable. Some peak blocks may make only a single trip to augment peak period service or to add service during school peaks. Although single trips may serve an important need, single trip blocks are costly, especially when they require a dedicated peak vehicle. Interlining with another block is almost always desirable.

- **It is not necessary to provide recovery time at both ends of the route.** For Route 110, recovery is generally made at DVC or the rail station (CON). Since this route is designed to meet trains, some layover is planned at the rail station regardless of whether this is actually a terminal for some trips. A target total of between 5 and 10 minutes of layover is to be included for each round trip, including time given at DVC, the outer terminals and the rail station.

- **Tracking trip assignments to blocks on the master schedule** reduces the chance of error. A common mistake occurs when the scheduler inadvertently misses single trips in the blocking thread. If not caught in time, this could result in extensive reworking.

The following pages contain the master schedule (headway sheet) for Route 110 (by direction) and a blocking sheet form which displays multiple terminals. The initial set of blocks will be developed from the master schedule and recorded on the blocking sheet form.

A. Route 110 master schedule - westbound

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49
2W	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04
3W	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21
4W	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36
5W	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51
6W	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01
7W	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13
8W	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23
9W	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33
10W	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43
11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
15W	K		7:55		8:04	8:09	8:15	8:24	Out of service		
16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
17W	P		8:09	8:17		8:23	8:29	8:38	Out of service		
18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	K		8:29		8:38	8:42	8:47	8:56	Out of service		
20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	P		9:00	9:07		9:11	9:16	9:25	Out of service		
22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57
29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
39W	K		2:44S		2:51S						
40W	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
48W	--								5:35	5:41	5:54
49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24
58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41
60W	K		7:07		7:15	7:19	7:24	7:32	Out of service		
61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06
62W	P		7:28	7:35		7:39	7:44	7:52	Out of service		
63W	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26
64W	M	8:00	8:08			8:11	8:16	8:24	Out of service		
65W	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56
66W	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26
67W	M	9:00	9:08			9:11	9:16	9:24			
68W	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06
69W	K		9:53		10:01	10:05	10:10	10:18	Out of service		
70W	P		10:24	10:31		10:35	10:40	10:48	Out of service		
71W	K		10:53		11:01	11:05	11:10	11:18	Out of service		

Route 110 /WESTbound

B. Route 110 master schedule - eastbound

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P				**4:43**	4:49	4:53		4:57	5:04	
2E	K				**4:59**	5:05	5:09	5:13		5:21	
3E	P				**5:05**	5:11	5:15		5:19	5:27	
4E	M				**5:21**	5:27	5:31			5:34	5:42
5E	K				**5:36**	5:44	5:49	5:53		6:02	
6E	P				**5:45**	5:53	5:58		6:03	6:11	
7E	M	**5:30**	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8E	K	**5:44**	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
9E	P	**5:54**	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
27E	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
45E	K				4:12	4:22	4:29	4:34		4:44	
46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
48E	K				4:50	5:00	5:07	5:12		5:22	
49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
50E	M				5:10	5:20	5:27			5:30	5:44
51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
52E	P				5:30	5:40	5:47		5:52	6:00	
53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
56E	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	
59E	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
60E	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
61E	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
62E	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
65E	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
66E	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
67E	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
68E	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
69E	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

Route 110 /EASTbound

C. Sample blocking sheet - multiple terminals

BLOCKING SHEET
Multiple Terminals

Route #: Special Instructions:

Date:

Scheduler:

	Inbound				Outbound			
Block No.	Depart Outer Terminal 1	Depart Outer Terminal 2	Arrive Inner Terminal 1	Arrive Inner Terminal 2	Depart Inner Terminal 2	Depart Inner Terminal 1	Arrive Outer Terminal 2	Arrive Outer Terminal 1

A sample blocking sheet (multiple terminals) form

III. Beginning the Blocking Process for Route 110

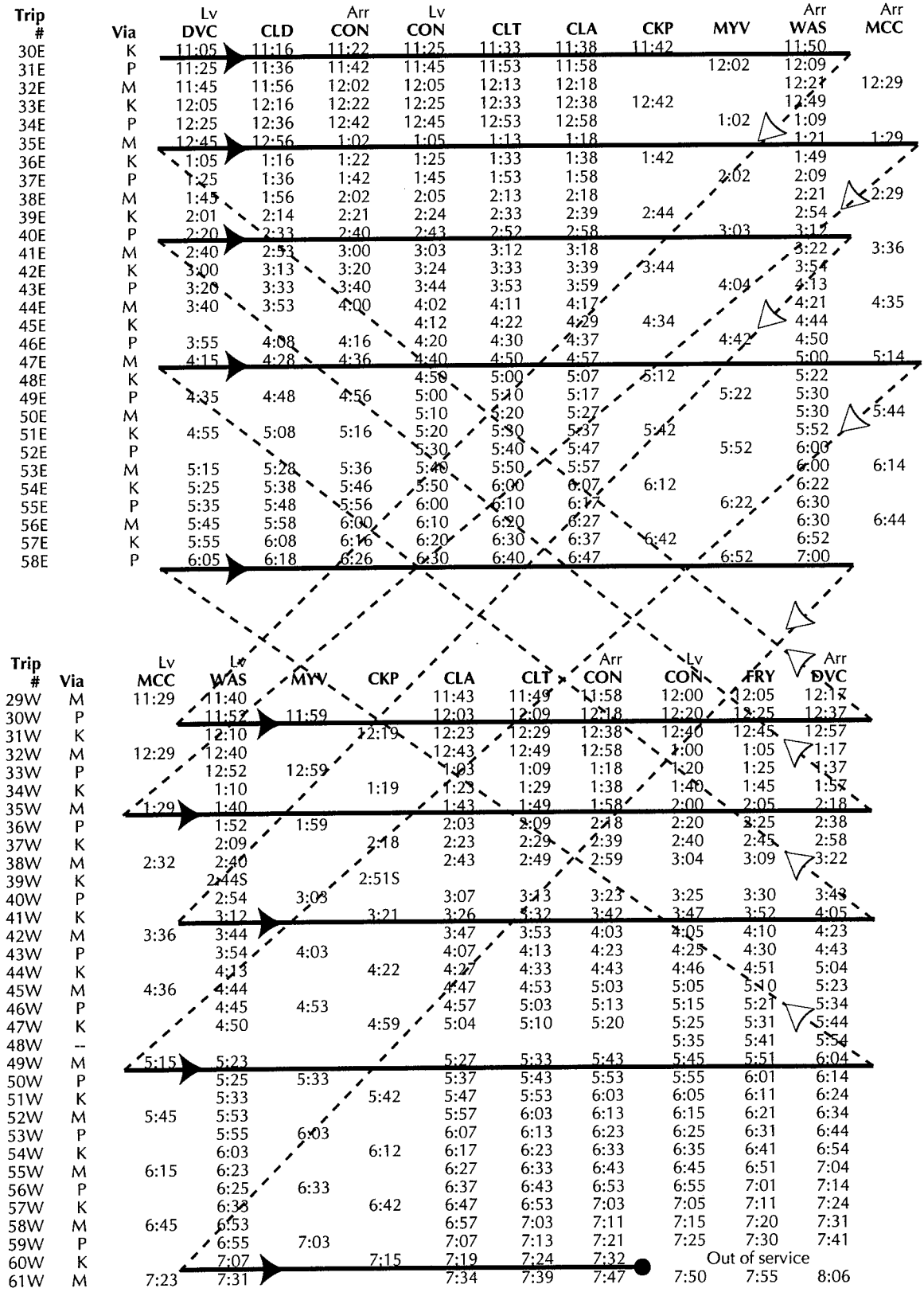
The first eastbound Route 110 trip 1E leaves the rail station (CON) at 4:43 a.m., arriving at Washington and Clayton (WAS) at 5:04 a.m. Trip 1W departs from WAS at 5:04 a.m., arriving at DVC at 5:49 a.m. By taking no layover at WAS, 1E can be hooked to 1W and together form the first two trips of Block 1. Logical hooks for Block 1 continue as shown and are summarized on the blocking sheet that follows. The hooks occur smoothly because blocking considerations were taken into account by the scheduler during the trip generation process.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	P				4:43	4:49	4:53		4:57	5:04	
2E	K				4:59	5:05	5:09	5:13		5:21	
3E	P				5:05	5:11	5:15		5:19	5:27	
4E	M				5:21	5:27	5:31			5:34	5:42
5E	K				5:36	5:44	5:49	5:53		6:02	
6E	P				5:45	5:53	5:58		6:03	6:11	
7E	M	5:30	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8E	K	5:44	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
9E	P	5:54	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
27E	K	10:05	10:16	10:23	10:25	10:38	10:42	10:42		10:50	
28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	K		5:04		5:13	5:17	5:22	5:30	5:33	5:38	5:49
2W	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04
3W	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21
4W	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36
5W	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51
6W	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01
7W	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13
8W	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23
9W	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33
10W	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43
11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
15W	K		7:55		8:04	8:09	8:15	8:24	Out of service		
16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
17W	P		8:09	8:17		8:23	8:29	8:38	Out of service		
18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	K		8:29		8:38	8:42	8:47	8:56	Out of service		
20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	P		9:00	9:07		9:11	9:16	9:25	Out of service		
22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57

Blocking Route 110 begins with Block 1.

Completing Block 1 Route 110



Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
45E	K				4:12	4:22	4:29	4:34		4:44	
46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
48E	K				4:50	5:00	5:07	5:12		5:22	
49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
50E	M				5:10	5:20	5:27			5:30	5:44
51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
52E	P				5:30	5:40	5:47		5:52	6:00	
53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
56E	M	5:45	5:58	6:06	6:10	6:20	6:27			6:30	6:44
57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
39W	K		2:44S		2:51S						
40W	P		2:54	3:08		3:07	3:13	3:23	3:25	3:30	3:43
41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
48W	--								5:35	5:41	5:54
49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
57W	K		6:38		6:42	6:47	6:53	7:03	7:05	7:11	7:24
58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41
60W	K		7:07		7:15	7:19	7:24	7:32	Out of service		
61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06

Route 110 Block 1 is completed.

Notes:

- A target of at least 4 minutes of "internal" recovery time has been provided for each round trip at the rail station (CON) during the trip building process. This availability of internal recovery time makes it possible to minimize recovery at the eastern and western terminals and still meet contractual layover requirements.

- Block 1 switches from the Washington @ Clayton (WAS) branches to the Marsh Creek Circle (MCC) branch as per the route design and because of the way the scheduler has made decisions regarding the layover allocations. The vehicle assigned to Block 1 can change between route branches at the common terminal DVC.

- When arrival and departure times are the same, the terminal is treated as a simple stop, with no recovery at that location.

- On the blocking sheet that follows, the terminal locations have been customized to name the exact location rather than "outer" and "inner" terminals.

A. Blocking sheet completed for Route 110, Block 1

BLOCKING SHEET
Multiple Terminals

Route #: 110

Date: xx/xx/xx

Scheduler: BN

Special Instructions: 5 - 10 min. recovery/ layover. Consider internal layover at rail station as part of total amount required.

	Westbound				Eastbound			
Block No.	Depart Wash/ Clay (WAS)	Depart Marsh Crk Cr (MCC)	Arrive Rail Station (CON)	Arrive DVC	Depart DVC	Depart Rail Station (CON)	Arrive Wash/ Clay (WAS)	Arrive Marsh Crk Cr (MCC)
1						4:43A	5:04A	
1	5:04			5:49	5:54		6:41	
1	6:41			7:33	7:34		8:14	
1	8:14			9:14	9:25		10:09	
1	10:11			10:59	11:05		11:50	
1	11:52A			12:37P	12:45P			1:29P
1		1:29		2:18	2:20		3:12	
1	3:12			4:05	4:15			5:14
1		5:15		6:04	6:05		7:00	
1	7:07P		7:32P					

Eighteen Route 110 one-way trips make up Block 1.

Block 1 is an all day (base) block that begins at the rail station. During the course of the day, Block 1 provides some trips to the Washington and Clayton (WAS) terminal and some to the Marsh Creek Circle terminal. The operator will simply change the destination sign (headsign) at the DVC terminal before turning around.

B. Block 2, Route 110

The second block (Block 2) derived from the master schedule also provides all day service, operating nearly 15 hours in revenue service. Block 3 operates in the morning only.

BLOCKING SHEET

Route #: 110

Date: xx/xx/xx

Scheduler: BN

Special Instructions: 5 - 10 min. recovery/ layover. Consider internal layover at rail station as part of total amount required.

	Westbound				Eastbound			
Block No.	Depart Wash/ Clay (WAS)	Depart Marsh Crk Cr (MCC)	Arrive Rail Station (CON)	Arrive DVC	Depart DVC	Depart Rail Station (CON)	Arrive Wash/ Clay (WAS)	Arrive Marsh Crk Cr (MCC)
2						4:59A	5:21A	
2	5:21			6:04	6:14		7:02	
2	7:02			7:53	7:55			8:40
2		8:40		9:32	9:45			10:29
2		10:29A		11:19A	11:25A		12:09P	
2	12:10			12:57	1:05		1:49	
2	1:52			2:38	2:40			3:36
2		3:36		4:23	4:35		5:30	
2	5:33			6:24	6:35		7:24	
2	7:28P		7:52P					
3						5:05A	5:27A	
3	5:31			6:21	6:23		7:11	
3	7:11			8:03	8:10		8:55	
3	9:00A		9:25A					

The blocking of Route 110 continues with the completion of Blocks 2 and 3.

Several considerations come into play while continuing the blocking of Route 110:

1) Trips begin at more than one location. For example, while most of the morning pull-outs begin revenue service at the rail station, some begin at DVC.

2) Route 110 contains school tripper service which requires a vehicle to operate just one trip (or partial trip). On the master schedule, the school trip is marked with an S.

3) Some blocks will operate all day, while others will operate during just one peak period.

C. Completing the blocks for Route 110

BLOCKING SHEET

Route #: 110

Date: xx/xx/xx

Scheduler: BN

Special Instructions: 5 - 10 min. recovery/ layover. Consider internal layover at rail station as part of total amount required.

	Westbound				Eastbound			
Block No.	Depart Wash/ Clay (WAS)	Depart Marsh Crk Cr (MCC)	Arrive Rail Station (CON)	Arrive DVC	Depart DVC	Depart Rail Station (CON)	Arrive Wash/ Clay (WAS)	Arrive Marsh Crk Cr (MCC)
4						5:21A		5:42
4		4:43		6:36	6:38			7:23
4		7:24		8:18	8:25		9:09	
4	9:11			9:59	10:05		10:50	
4	10:52A			11:37A	11:45A			12:29P
4		12:29		1:17	1:25		2:09	
4	2:09			2:58	3:00		3:54	
4	4:54			4:43	4:55		5:52	
4	5:55			6:44	6:50		7:38	
4	7:42			8:26	8:40		9:24	
4	9:24			10:06	10:10		10:53	
4	10:53P		11:18P					
5						5:36A	6:02A	
5	6:02			6:51	6:53		7:39	
5	7:39			8:34	8:45			9:29
5		9:29		10:19	10:25		11:09	
5	11:10A			11:57A	12:05P		12:49	
5	12:52			1:37	1:45			2:29
5		2:32		3:22	3:40			4:35
5		4:36		5:23	5:25		6:22	
5	6:25P			7:14P				
6						5:45A	6:11A	
6	6:11			7:01	7:08		7:55	
6	7:55A		8:24A					
7					5:30A			6:17A
7		6:18		7:13	7:14			7:55
7		8:00		8:54	9:05		9:50	
7	9:53			10:39	10:45			11:29
7		11:29A		12:17P	12:25P		1:09P	
7	1:10			1:57	2:01		2:54	

The blocking of Route 110 continues.

BLOCKING SHEET

Route #: 110

Date: xx/xx/xx

Scheduler: BN

Special Instructions: 5 - 10 min recovery/ layover. Consider internal layover at rail station as part of amount required at terminal.

	Westbound				Eastbound			
Block No.	Depart Wash/ Clay (WAS)	Depart Marsh Crk Cr (MCC)	Arrive Rail Station (CON)	Arrive DVC	Depart DVC	Depart Rail Station (CON)	Arrive Wash/ Clay (WAS)	Arrive Marsh Crk Cr (MCC)
7	2:54			3:43	3:55		4:50	
7	4:50			5:44	5:45			6:44
7		6:45P		7:31P				
8					5:44A		6:32A	
8	6:32			7:23	7:24		8:09	
8	8:09A		8:38A					
9					6:00A			6:47A
9		6:48		7:43	7:44		8:29	
9	8:29A		8:56A					
10					3:20P		4:13P	
10	4:13			5:04	5:15			6:14
10		6:15		7:04	7:10			7:57
10		8:00P	8:24P					
11						4:12P	4:44P	
11	4:45			5:34	5:35		6:30	
11	6:33			7:24	7:30		8:14	
11	8:14			8:56	9:10		9:53	
11	9:53P		10:18P					
12						4:50P	5:22P	
12	5:25			6:14	6:20			7:17
12		7:23		8:06	8:10			8:57
12		9:00P	9:24P					
13						5:10P		5:44
13		5:45P		6:34P				
14						5:30P	6:00P	
14		6:03P		6:54P				

The blocking of Route 110 continues.

BLOCKING SHEET

Route #: 110

Date: xx/xx/xx

Scheduler: BN

Special Instructions: 5 - 10 min recovery/ layover. Consider internal layover at rail station as part of amount required at terminal.

	Westbound				Eastbound			
Block No.	Depart Wash/ Clay (WAS)	Depart Marsh Crk Cr (MCC)	Arrive Rail Station (CON)	Arrive DVC	Depart DVC	Depart Rail Station (CON)	Arrive Wash/ Clay (WAS)	Arrive Marsh Crk Cr (MCC)
15			5:35P	5:54P	5:55P		6:52P	
15	6:55			7:41	7:50		8:33	
15	8:37			9:26	9:40		10:24	
15	10:24P		10:48P					
16(S)	2:44P		2:51 CKP					

The blocking sheet contains the final blocks.

D. Observations about the completed blocks

- Block 3 is the first of the peak only blocks. It runs only during the morning peak, from 5:05 a.m. to 9:25 a.m. This block pulls in and out at the rail station, providing bus to rail feeder service for morning commuters. Blocks 6, 8, and 9 also operate only during the morning peak.

- Block 16(S) is a special block that operates only on school days. It is the only block that pulls off the line at Concord @ Kirker Pass (CKP) and the only block that does not serve the rail station (CON).

- Blocks 13 and 14 operate only during the P.M. peak. Blocks 10, 11, 12 and 15 pull out in the P.M. peak, but continue into the evening period as well.

E. Noting block numbers on the master schedule

Double checking that all trips have been blocked is commonly done by noting the block number next to the trip number on the master schedule. Directional Route 110 master schedules with block notations are shown on the following pages.

Block #	Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1 -	1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49
2 -	2W	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04
3 -	3W	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21
4 -	4W	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36
5 -	5W	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51
6 -	6W	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01
7 -	7W	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13
8 -	8W	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23
1 -	9W	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33
9 -	10W	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43
2 -	11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
3 -	12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
4 -	13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
5 -	14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
6 -	15W	K		7:55		8:04	8:09	8:15	8:24	Out of service		
7 -	16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
8 -	17W	P		8:09	8:17		8:23	8:29	8:38	Out of service		
1 -	18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
9 -	19W	K		8:29		8:38	8:42	8:47	8:56	Out of service		
2 -	20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
3 -	21W	P		9:00	9:07		9:11	9:16	9:25	Out of service		
4 -	22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
5 -	23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
7 -	24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
1 -	25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
2 -	26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
4 -	27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
5 -	28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57
7 -	29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
1 -	30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
2 -	31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
4 -	32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
5 -	33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
7 -	34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
1 -	35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
2 -	36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
4 -	37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
5 -	38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
16(S)	39W	K		2:44S		2:51S						
7 -	40W	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
1 -	41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
2 -	42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
4 -	43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
10 -	44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
5 -	45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
11 -	46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
7 -	47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
15 -	48W	--								5:35	5:41	5:54
1 -	49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
12 -	50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
7 -	51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
13 -	52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
4 -	53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
14 -	54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
10 -	55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
5 -	56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
11 -	57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24
7 -	58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
15 -	59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41
1 -	60W	K		7:07		7:15	7:19	7:24	7:32	Out of service		
12 -	61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06
2 -	62W	P		7:28	7:35		7:39	7:44	7:52	Out of service		
4 -	63W	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26
10 -	64W	M	8:00	8:08			8:11	8:16	8:24	Out of service		
11 -	65W	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56
15 -	66W	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26
12 -	67W	M	9:00	9:08			9:11	9:16	9:24			
4 -	68W	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06
11 -	69W	K		9:53		10:01	10:05	10:10	10:18	Out of service		
15 -	70W	P		10:24	10:31		10:35	10:40	10:48	Out of service		
4 -	71W	K		10:53		11:01	11:05	11:10	11:18	Out of service		

Route 110 /WESTbound with block notations

Block #	Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1 -	1E	P				**4:43**	4:49	4:53		4:57	5:04	
2 -	2E	K				**4:59**	5:05	5:09	5:13		5:21	
3 -	3E	P				**5:05**	5:11	5:15		5:19	5:27	
4 -	4E	M				**5:21**	5:27	5:31			5:34	5:42
5 -	5E	K				**5:36**	5:44	5:49	5:53		6:02	
6 -	6E	P				**5:45**	5:53	5:58		6:03	6:11	
7 -	7E	M	**5:30**	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8 -	8E	K	**5:44**	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
1 -	9E	P	**5:54**	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
9 -	10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
2 -	11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
3 -	12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
4 -	13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
5 -	14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
6 -	15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
7 -	16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
8 -	17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
1 -	18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
9 -	19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
2 -	20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
3 -	21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
4 -	22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
5 -	23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
7 -	24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
1 -	25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
2 -	26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
4 -	27E	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
5 -	28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
7 -	29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
1 -	30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
2 -	31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
4 -	32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
5 -	33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
7 -	34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
1 -	35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
2 -	36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
4 -	37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
5 -	38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
7 -	39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
1 -	40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
2 -	41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
4 -	42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
10 -	43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
5 -	44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
11 -	45E	K				4:12	4:22	4:29	4:34		4:44	
7 -	46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
1 -	47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
12 -	48E	K				4:50	5:00	5:07	5:12		5:22	
7 -	49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
13 -	50E	M				5:10	5:20	5:27			5:30	5:44
4 -	51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
14 -	52E	P				5:30	5:40	5:47		5:52	6:00	
10 -	53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
5 -	54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
11 -	55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
7 -	56E	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
15 -	57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
1 -	58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	
12 -	59E	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
2 -	60E	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
4 -	61E	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
10 -	62E	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
11 -	63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
15 -	64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
12 -	65E	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
4 -	66E	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
11 -	67E	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
15 -	68E	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
4 -	69E	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

Route 110 /EASTbound with block notations

F. Completing the block summary recap form

After the blocking sheet is completed and block numbers are noted on the master schedule, the block summary recap is useful for displaying block pull-out and pull-in times and pull-on and pull-off locations as well as the first and last revenue times. The block summary recap form below is completed for the Route 110 blocks.

BLOCK SUMMARY RECAP

Route #: 110 Special Instructions:

Date: xx/xx/xx

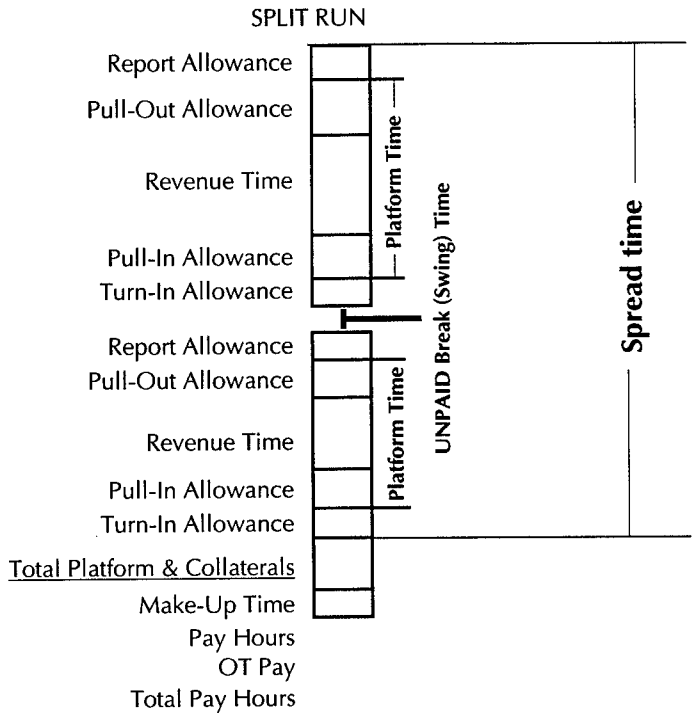
Scheduler:

BLOCK No.	PULL-OUT TIME (Time out)	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME (Time in)
1		CON	4:43A	7:32P	CON	
2		CON	4:59A	7:52P	CON	
3		CON	5:05A	9:25A	CON	
4		CON	5:21A	11:18P	CON	
5		CON	5:36A	7:14P	DVC	
6		CON	5:45A	8:24A	CON	
7		DVC	5:30A	7:31P	DVC	
8		DVC	5:44A	8:38A	CON	
9		DVC	6:00A	8:56A	CON	
10		DVC	3:20P	8:24P	CON	
11		CON	4:12P	10:18P	CON	
12		CON	4:50P	9:24P	CON	
13		CON	5:10P	6:34P	DVC	
14		CON	5:30P	6:54P	DVC	
15		CON	5:35P	10:48P	CON	
16(S)		WAS	2:44P	2:51P	CKP	

Route 110 blocks summarized on a block summary recap form

IV. Evaluating the Blocks

Efficient runcutting (see chapter 4) depends on how "well" the blocks can be "cut" into runs. Of prime consideration is how well the blocks cut so that any split runs will conform to spread restrictions.



Restrictions generally apply based on the length of spread time for two or more block pieces that are tied together into one operator assignment (run). When split runs exceed the maximum spread limit, they may be considered "illegal" runs. Spread limits may also be imposed at lesser spread times and result in spread penalties (additional pay).

Therefore, evaluating the blocks for efficient runcutting is an important step in the scheduling process. To facilitate this process, block graphs can be extremely useful.

Exceeding spread time limits may result in illegal runs or spread penalties

A. Block graphs

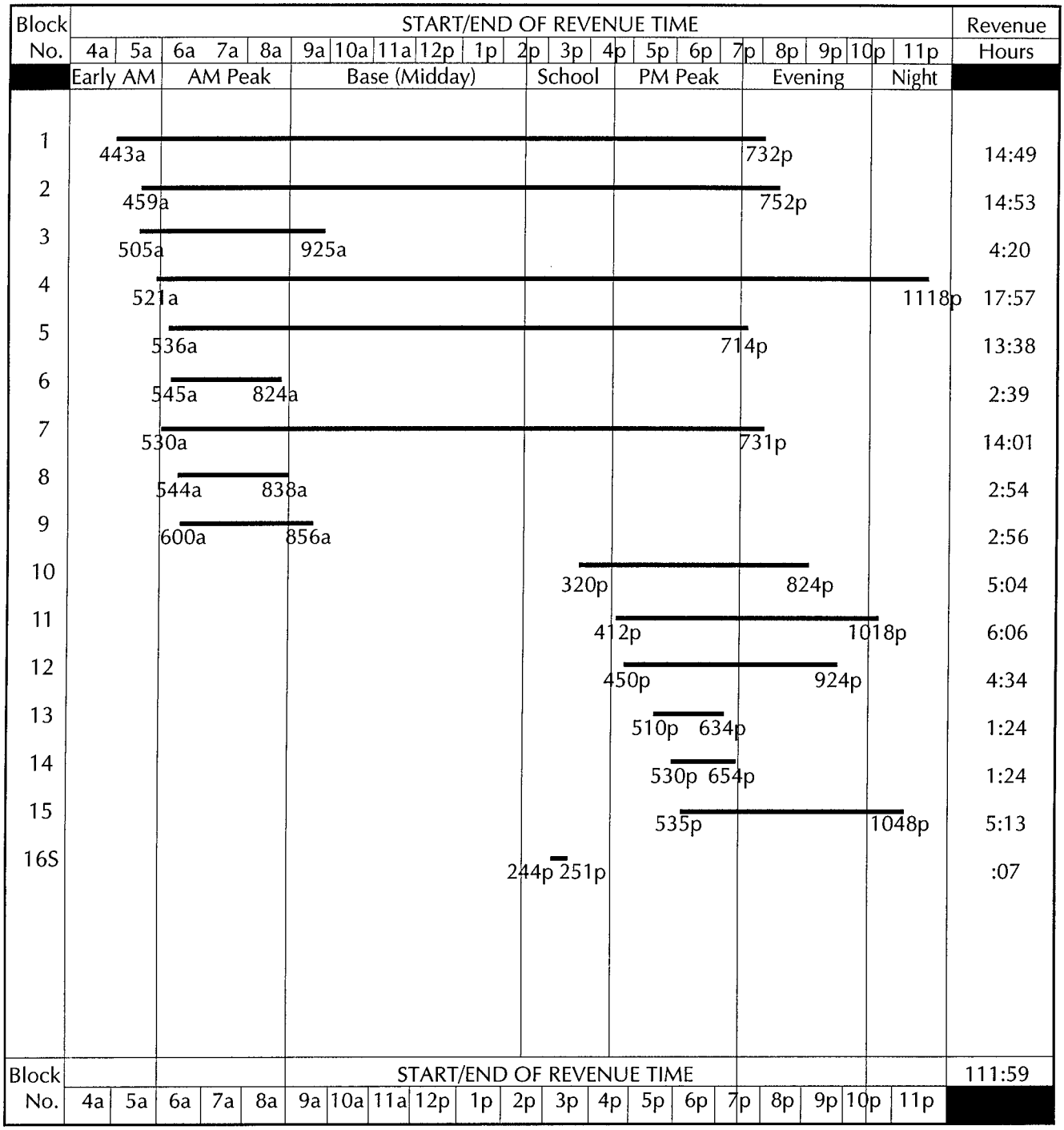
A graph of the initial Route 110 blocks follows. This block graph displays revenue service hours for each block rather than platform time (which includes pull-out and pull-in times). Revenue hours display is desirable at this stage in order to assess the start and end times of potential candidate pairings. If platform times were displayed, garage deadhead times would have to be deducted first before candidate pairings could be evaluated.

A number of observations can be made about this block graph:

- The length of four of the P.M. peak blocks (Blocks 10, 11, 12 and 15) is not conducive to efficient runcutting. They are not long enough to be stand-alone straight runs without granting excessive make-up time. Consequently they are likely candidates to be considered for split runs. However, all four operate too late into the evening to be coupled with existing A.M. pieces without creating illegal runs or paying excessive spread penalties.

- Block 16S is a very small piece of work. It is not practical for it to remain a separate block.

- The current base blocks appear to lend themselves to various cutting options given that on-street reliefs can be made at the rail station (arrival time only) and at DVC (arrival time only).



Initial Route 110 blocks

With the observations on the previous page in mind, the next step is to evaluate ways to re-block some of the trips so that the resultant runs conform to spread restrictions and effectively utilize available resources.

B. Re-blocking Block 10 (Block 4)

Block 10 starts revenue service too early (3:20 p.m.) to be preceded by another current P.M. block and Block 10 ends too late (8:24 p.m.) to fall into an acceptable spread range if it were combined with a current A.M. piece to form a split run.

The scheduler has decided to check the master schedule to see what other trips are hooked just prior to Block 10's DVC 3:20 p.m. departure time. It is discovered that Block 4, trip 42E departs DVC at 3:00 p.m.

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
4 - 42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
10 - 43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	

Block 10 now starts here

What if Block 4 ended its current set of trip hooks at 3:00 p.m. and took on the current Block 10 trips at 3:20 p.m. – and Block 10 took over the original Block 4 trips beginning at 3:00 p.m.?

1) A Block 4 20-minute layover would occur at DVC (3:00 p.m. to 3:20 p.m.).
2) New Block 4 trips would still begin at 5:21 a.m. but now end at 8:24 p.m. (15:03 total revenue service).
3) Block 10 trips would begin at 3:00 p.m. and end at 11:18 p.m. (8:18 total revenue service).
4) Total revenue hours would be 112:19 (an increase of 20 minutes).
5) Revised Block 4 would still be a base block and of sufficient length to cut into two runs.
6) Revised Block 10 would be a P.M. straight run.
7) The spread problem associated with the original Block 10 would be eliminated.

The adjustment appears appropriate and is reflected in the revised block graph shown on the next page. The "cost" of this adjustment is an increase of :20 in layover. However, the elimination of the spread problem justifies this move. The use of colored pencils is a good way to track incremental actions when noting blocking adjustments on the master schedule.

C. Re-blocking Block 11 (Block 5)

Blocks 11, 12 and 15 demonstrate similar characteristics as the original Block 10. However, because they start "later," there might be a possibility of hooking blocks that finish earlier onto the front. The only apparent possibility would be 16S, but the excessive layover at the rail station would tend to prohibit this move.

The scheduler could consider hooking the later trips associated with Blocks 11, 12 and 15 into base Blocks 1, 2, 5 or 7. This would make Blocks 11, 12 and 15 shorter in length and could turn them into trippers or second pieces of split runs. The base blocks, with the addition of the later trips, could still be of sufficient length to cut into two straight runs.

Block 5, trip 56W finishes at DVC at 7:14 p.m. and immediately precedes Block 11, trip 57W which arrives at DVC at 7:24 p.m. Block 11 then hooks to the 7:30 p.m. departure trip 63E. Re-hooking the 7:30 p.m. departure from Block 11 to Block 5, along with subsequent Block 11 trips, results in an end revenue time of 7:24 p.m. for the revised Block 11.

Block 5 ends here

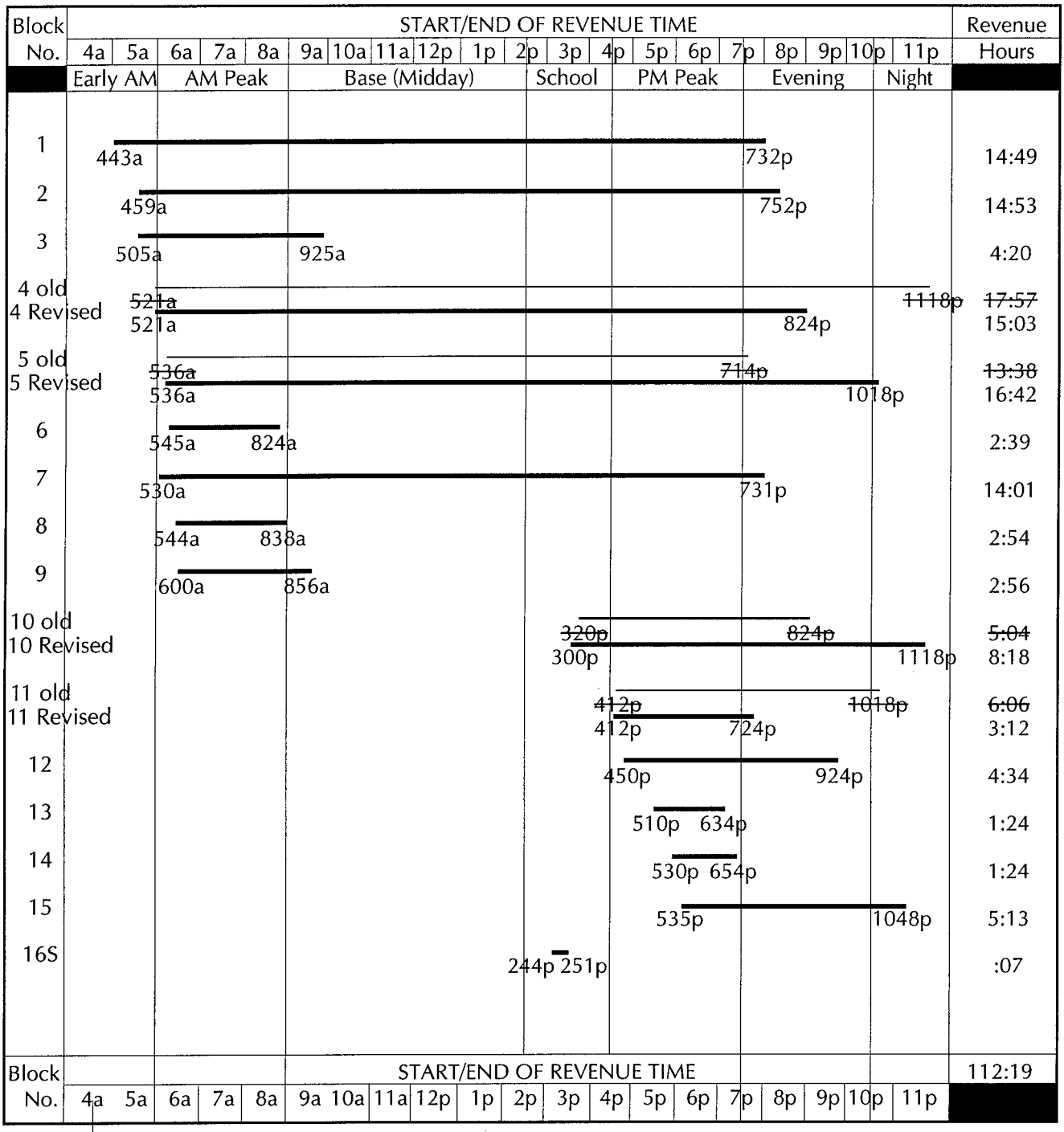
Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
5 - 56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
11 - 57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24

Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
11 - 63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	

What if Block 5 took on the current Block 11 trips starting with trip 63E from DVC at 7:30 p.m.?

1) Layover at DVC would be 16 minutes (7:14 p.m. to 7:30 p.m.).
2) Total revenue hours would increase to 112:29 (a 10 minute increase).
3) Revised Block 11 would become a P.M. piece (4:12 p.m. to 7:24 p.m.), better suited as the P.M. part of a split run.
4) Revised Block 5 would still be a base block of sufficient length (5:36 a.m. to 10:18 p.m.) to cut into two straight runs (16:42).

D. Block graphs revised for Blocks 4 &10 and 5 & 11



Block graph for Route 110 - revisions to Blocks 4, 5, 10 and 11

E. Re-blocking Block 15 (Block 7)

A similar situation exists for Block 15. It is not long enough (5:13) to cut into a straight run and it ends too late (10:48 p.m.) to be the second piece of a split run (excessive spread time). Again, the scheduler looks at the possibility of re-hooks.

Block 15, trip 59W arrives at DVC at 7:41 p.m., then continues as trip 64E, departing DVC at 7:50 p.m. Block 7, trip 58W, is currently finished for the day at DVC at 7:31 p.m. By rehooking 64E (and subsequent Block 15 trips) onto Block 7, Block 15 would then finish for the day at DVC at 7:41 p.m.

Block 7 now finishes here

	Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
7 -	58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
15 -	59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41

Current Block 15 hook

	Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
15-	64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	

What would be the consequences of rehooking 64E and subsequent Block 15 trips onto Block 7 and ending Block 15 at 7:41p.m.?

1) A 19-minute layover for Block 7 at DVC (7:31 p.m. to 7:50 p.m.).
2) Total revenue hours would increase to 112:39 (a 10 minute increase).
3) Revised Block 15 would be a P.M. tripper piece of 2:09 (5:35 p.m. to 7:41 p.m.).
4) Revised Block 7 would still be a base block of sufficient length, 17:18 (5:30 a.m. to 10:48 p.m.) to cut into two straight runs.

F. Re-blocking Block 12 (Block 1)

As with Block 15 above, Block 12 is not long enough to cut into a straight run (4:34) and it ends too late 9:24 p.m.) to be the second piece of a split run (excessive spread time). The master schedule provides the following possibility.

Block 12, trip 61W, arrives at the rail station (CON) at 7:47 p.m. and is scheduled to depart CON at 7:50 p.m. Block 1, trip 60W, arrives at CON at 7:32 p.m. (15 minutes prior to Block 12) and is scheduled to go out of service at that time and location. By rehooking Block 12's scheduled 7:50 p.m. departure from CON to Block 1, Block 12 could be finished at 7:47 p.m.

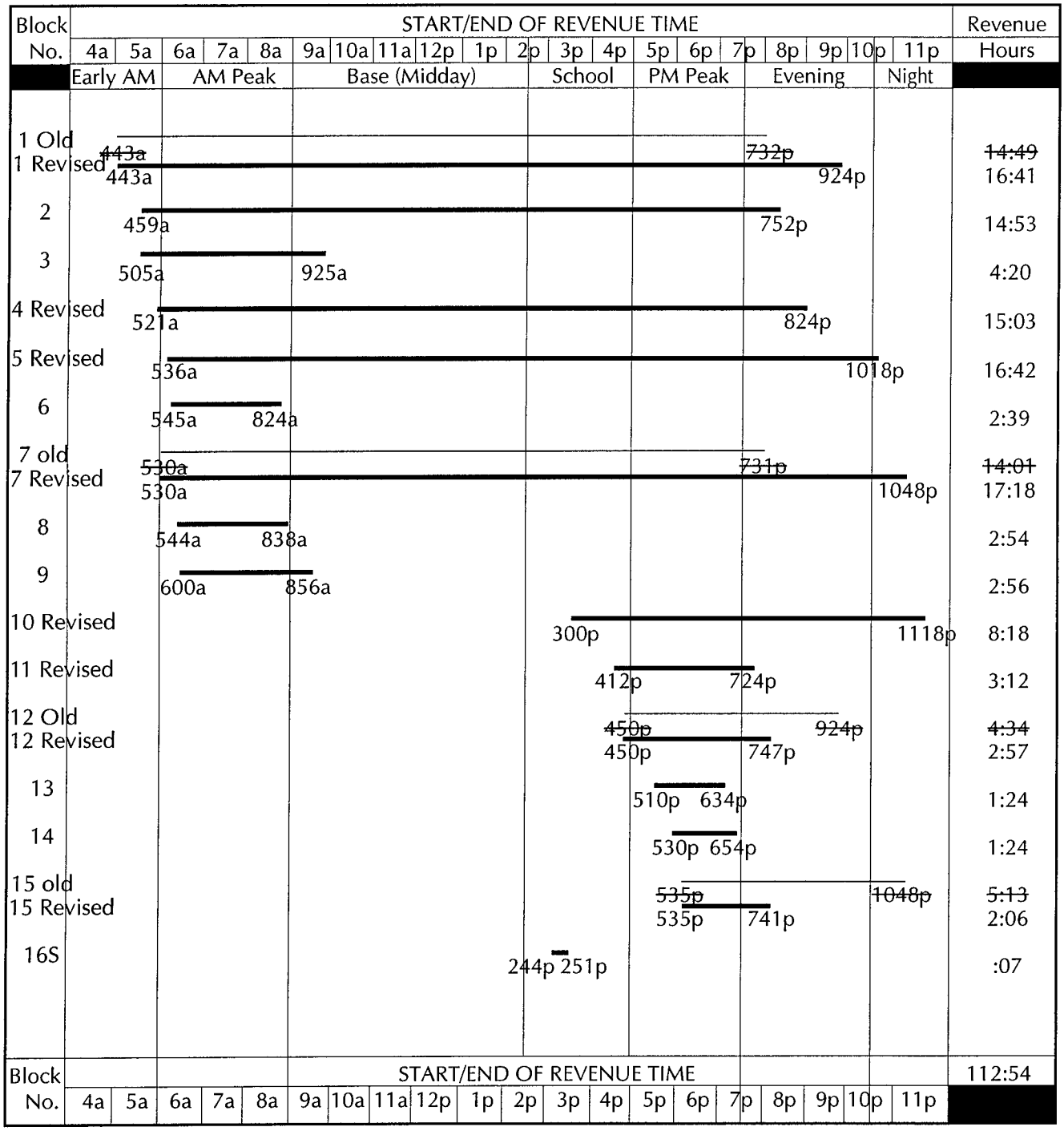
	Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1 -	60W	K		7:07		7:15	7:19	7:24	7:32	Out of service		
12 -	61W	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06

What would be the results of ending Block 12 at CON at 7:47 p.m. and having Block 1 make subsequent Block 12 trips?

1) Block 1 layover at CON would be 18 minutes (7:32 p.m. to 7:50 p.m.).
2) Total revenue hours would be 112:54.
3) Revised Block 12 would be a P.M. tripper piece of 2:57 (4:50 p.m. to 7:47 p.m.).
4) Revised Block 1, now ending at 9:24 p.m., is still a base block of sufficient length (16:41) to cut into two straight runs.

The revisions to Blocks 15, 7, 12 and 1 are shown on the block graph on the following page.

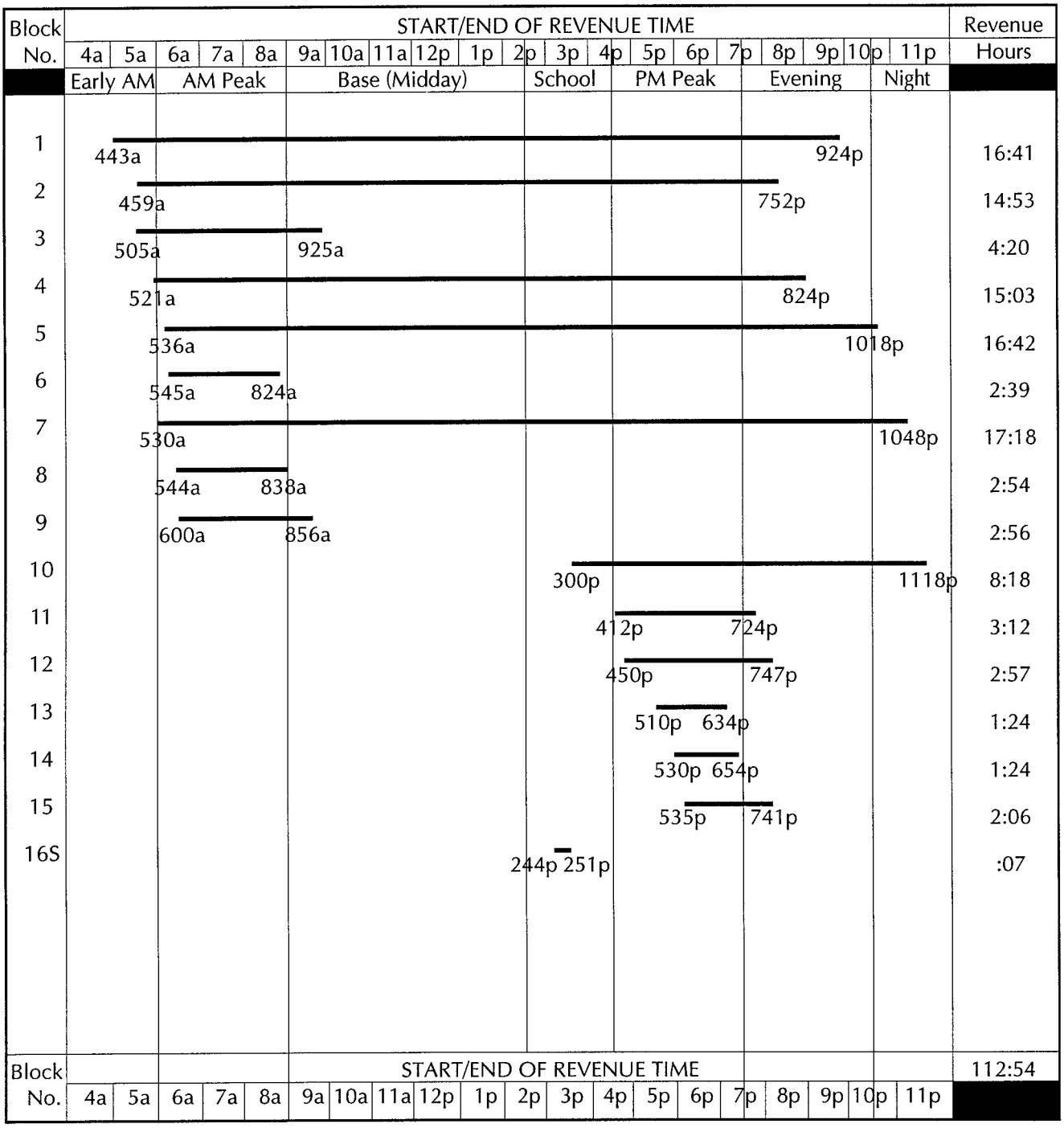
G. Block graphs revised for Blocks 7 & 15 and 1 & 12



Block graph for Route 110 - revisions to Blocks 1, 7, 12 and 15

Block 16S, although undesirable, remains unchanged. The scheduler has determined that further analysis will take place in the runcutting process where other route pieces will be available.

H. Final Route 110 block graph



Final block graph for Route 110

I. Revised Master Schedule (with notations for new blocks)

Block #	Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC	
1	- 1W	K		5:04		5:13	5:17	5:22	**5:30**	5:33	5:38	5:49	
2	- 2W	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04	
3	- 3W	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21	
4	- 4W	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36	
5	- 5W	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51	
6	- 6W	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01	
7	- 7W	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13	
8	- 8W	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23	
1	- 9W	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33	
9	- 10W	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43	
2	- 11W	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53	
3	- 12W	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03	
4	- 13W	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18	
5	- 14W	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34	
6	- 15W	K		7:55		8:04	8:09	8:15	8:24	Out of service			
7	- 16W	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54	
8	- 17W	P		8:09	8:17		8:23	8:29	8:38	Out of service			
1	- 18W	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14	
9	- 19W	K		8:29		8:38	8:42	8:47	8:56	Out of service			
2	- 20W	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32	
3	- 21W	P		9:00	9:07		9:11	9:16	9:25	Out of service			
4	- 22W	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59	
5	- 23W	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19	
7	- 24W	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39	
1	- 25W	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59	
2	- 26W	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19	
4	- 27W	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37	
5	- 28W	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57	
7	- 29W	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17	
1	- 30W	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37	
2	- 31W	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57	
4	- 32W	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17	
5	- 33W	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37	
7	- 34W	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57	
1	- 35W	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18	
2	- 36W	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38	
4	- 37W	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58	**to 3:20p**
5	- 38W	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22	
16(S)	39W	K		2:44S		2:51S							
7	- 40W	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43	
1	- 41W	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05	
2	- 42W	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23	
10	- 43W	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43	
4 10	- 44W	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04	
5	- 45W	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23	
11	- 46W	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34	
7	- 47W	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44	
15	- 48W	--								5:35	5:41	5:54	
1	- 49W	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04	
12	- 50W	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14	
2	- 51W	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24	
13	- 52W	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34	
10	- 53W	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44	
14	- 54W	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54	
4 10	- 55W	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04	
5	- 56W	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14	**to 7:30p**
11	- 57W	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24	
7	- 58W	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31	**to 7:50p**
15	- 59W	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41	
1	- 60W	K		7:07		7:15	7:19	7:24	7:32	Out of service			
12	- 61W	M	7:23	7:31			7:34	7:39	7:47 X	7:50	7:55	8:06	
2	- 62W	P		7:28	7:35		7:39	7:44	7:52	Out of service			
10	- 63W	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26	
4 10	- 64W	M	8:00	8:08			8:11	8:16	8:24	Out of service			
5 11	- 65W	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56	
7 15	- 66W	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26	
1 12	- 67W	M	9:00	9:08			9:11	9:16	9:24				
10	- 68W	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06	
5 11	- 69W	K		9:53		10:01	10:05	10:10	10:18	Out of service			
7 15	- 70W	P		10:24	10:31		10:35	10:40	10:48	Out of service			
10	- 71W	K		10:53		11:01	11:05	11:10	11:18	Out of service			

Revised Route 110 /WESTbound

Advanced Chapter 3/ Blocking

Block #	Trip #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1	- 1E	P				**4:43**	4:49	4:53		4:57	5:04	
2	- 2E	K				**4:59**	5:05	5:09	5:13		5:21	
3	- 3E	P				**5:05**	5:11	5:15		5:19	5:27	
4	- 4E	M				**5:21**	5:27	5:31			5:34	5:42
5	- 5E	K				**5:36**	5:44	5:49	5:53		6:02	
6	- 6E	P				**5:45**	5:53	5:58		6:03	6:11	
7	- 7E	M	**5:30**	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8	- 8E	K	**5:44**	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
1	- 9E	P	**5:54**	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
9	- 10E	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
2	- 11E	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
3	- 12E	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
4	- 13E	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
5	- 14E	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
6	- 15E	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
7	- 16E	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
8	- 17E	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
1	- 18E	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
9	- 19E	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
2	- 20E	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
3	- 21E	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
4	- 22E	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
5	- 23E	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
7	- 24E	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
1	- 25E	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
2	- 26E	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
4	- 27E	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
5	- 28E	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
7	- 29E	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
1	- 30E	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
2	- 31E	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
4	- 32E	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
5	- 33E	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
7	- 34E	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
1	- 35E	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
2	- 36E	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
4	- 37E	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
5	- 38E	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
7	- 39E	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
1	- 40E	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
2	- 41E	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
10	- 42E	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
4	- 43E	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
5	- 44E	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
11	- 45E	K				4:12	4:22	4:29	4:34		4:44	
7	- 46E	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
1	- 47E	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
12	- 48E	K				4:50	5:00	5:07	5:12		5:22	
7	- 49E	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
13	- 50E	M				5:10	5:20	5:27			5:30	5:44
10	- 51E	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
14	- 52E	P				5:30	5:40	5:47		5:52	6:00	
4	- 53E	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
5	- 54E	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
11	- 55E	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
7	- 56E	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
15	- 57E	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
1	- 58E	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	
12	- 59E	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
7	- 60E	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
10	- 61E	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
4	- 62E	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
5	- 63E	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
7	- 64E	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
1	- 65E	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
10	- 66E	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
5	- 67E	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
7	- 68E	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
10	- 69E	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

Revised Route 110 /EASTbound

J. Revised block summary recap

BLOCK SUMMARY RECAP

Route #: 110

Date: xx/xx/xx

Scheduler:

Special Instructions:

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
1	4:36A	CON	4:43A	9:24A	CON	9:31P	16:41	16:55
2	4:52A	CON	4:59A	7:52P	CON	7:59P	14:53	15:07
3	4:58A	CON	5:05A	9:25A	CON	9:32A	4:20	4:34
4	5:14A	CON	5:21A	8:24P	CON	8:31P	15:03	15:17
5	5:29A	CON	5:36A	10:18P	CON	10:25P	16:42	16:56
6	5:38A	CON	5:45A	8:24A	CON	8:31A	2:39	2:53
7	5:18A	DVC	5:30A	10:48P	CON	10:55P	17:18	17:37
8	5:32A	DVC	5:44A	8:38A	CON	8:45A	2:54	3:13
9	5:48A	DVC	6:00A	8:56A	CON	9:03A	2:56	3:15
10	2:48P	DVC	3:00P	11:18P	CON	11:25P	8:18	8:37
11	4:05P	CON	4:12P	7:24P	DVC	7:36P	3:12	3:31
12	4:43P	CON	4:50P	7:47P	CON	7:54P	2:57	3:11
13	5:03P	CON	5:10P	6:34P	DVC	6:46P	1:24	1:43
14	5:23P	CON	5:30P	6:54P	DVC	7:06P	1:24	1:43
15	5:28P	CON	5:35P	7:41P	DVC	7:53P	2:06	2:25
16S	2:09P	WAS	2:44P	2:51P	CKP	3:16P	:07	1:07
						Total	112:54	118:04

Finalized Route 110 block summary recap

CHAPTER 3: EXERCISES

- Block the Saturday Master Schedule for Route 110 below.
- Complete the Block Summary Recap below.
- Plot the Saturday blocks on the Block Graph on the following page.

Trip #	Via	Lv DVC	Arr CLD	Lv CON	Arr CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
-	-	-	-	-	-	-	-	-	-	-	-
1E	P		Into Service		6:55	7:03	7:08		7:12	7:19	
2E	K		Into Service		7:25	7:33	7:38	7:42		7:50	
3E	P		Into Service		7:55	8:03	8:08		8:12	8:19	
4E	K	7:58	8:09	8:15	8:25	8:33	8:38	8:42		8:50	
5E	P	8:28	8:39	8:45	8:55	9:03	9:08		9:12	9:19	
6E	K	8:58	9:09	9:15	9:25	9:33	9:38	9:42		9:50	
7E	P	9:28	9:39	9:45	9:55	10:03	10:08		10:12	10:19	
8E	K	9:58	10:09	10:15	10:25	10:33	10:38	10:42		10:50	
9E	P	10:28	10:39	10:45	10:55	11:03	11:08		11:12	11:19	
10E	K	10:58	11:09	11:15	11:25	11:33	11:38	11:42		11:50	
11E	P	11:28	11:39	11:45	11:55	12:03	12:08		12:12	12:19	
12E	K	11:58	12:09	12:15	12:25	12:33	12:38	12:42		12:50	
13E	P	12:28	12:39	12:45	12:55	13:03	13:08		13:12	13:19	
14E	K	12:58	13:09	13:15	13:25	13:33	13:38	13:42		13:50	
15E	P	13:28	13:39	13:45	13:55	14:03	14:08		14:12	14:19	
16E	K	13:58	14:09	14:15	14:25	14:33	14:38	14:42		14:50	
17E	P	14:28	14:39	14:45	14:53	15:03	15:10		15:15	15:23	
18E	K	14:57	15:08	15:16	15:23	15:33	15:40	15:45		15:55	
19E	P	15:25	15:38	15:46	15:53	16:03	16:10		16:15	16:23	
20E	K	15:55	16:08	16:16	16:23	16:33	16:40	16:45		16:55	
21E	P	16:25	16:38	16:46	16:54	17:04	17:11		17:16	17:24	
22E	K	16:55	17:08	17:16	17:24	17:34	17:41	17:46		17:56	
23E	P	17:25	17:38	17:46	17:54	18:04	18:11		18:16	18:24	
24E	K	17:58	18:09	18:15	18:25	18:33	18:38	18:42		18:50	
25E	P	18:28	18:39	18:45	18:55	19:03	19:08		19:12	19:19	
26E	K	18:58	19:09	19:15	19:25	19:33	19:38	19:42		19:50	
27E	P	19:58	20:09	20:15	20:25	20:33	20:38		20:42	20:49	
28E	K	20:58	21:09	21:15	21:25	21:33	21:38	21:42		21:50	
29E	P	21:58	22:09	22:15	-	-	-	-	-	-	

Trip #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	P		6:54	7:01		7:05	7:10	7:19	7:34	7:40	7:53
2W	K		7:24		7:33	7:37	7:42	7:51	8:04	8:10	8:23
3W	P		7:54	8:01		8:05	8:10	8:19	8:34	8:40	8:53
4W	K		8:24		8:33	8:37	8:42	8:51	9:04	9:10	9:23
5W	P		8:54	9:01		9:05	9:10	9:19	9:34	9:40	9:53
6W	K		9:24		9:33	9:37	9:42	9:51	10:04	10:10	10:23
7W	P		9:54	10:01		10:05	10:10	10:19	10:34	10:40	10:53
8W	K		10:24		10:33	10:37	10:42	10:51	11:04	11:10	11:23
9W	P		10:54	11:01		11:05	11:10	11:19	11:34	11:40	11:53
10W	K		11:24		11:33	11:37	11:42	11:51	12:04	12:10	12:23
11W	P		11:54	12:01		12:05	12:10	12:19	12:34	12:40	12:53
12W	K		12:24		12:33	12:37	12:42	12:51	13:04	13:10	13:23
13W	P		12:54	13:01		13:05	13:10	13:19	13:34	13:40	13:53
14W	K		13:24		13:33	13:37	13:42	13:51	14:04	14:10	14:23
15W	P		13:54	14:01		14:05	14:10	14:19	14:34	14:40	14:53
16W	K		14:24		14:33	14:37	14:42	14:51	15:04	15:10	15:23
17W	P		14:54	15:01		15:05	15:11	15:21	15:34	15:40	15:53
18W	K		15:23		15:32	15:37	15:43	15:53	16:04	16:10	16:23
19W	P		15:55	16:02		16:06	16:12	16:22	16:34	16:40	16:53
20W	K		16:23		16:32	16:37	16:43	16:53	17:04	17:10	17:23
21W	P		16:55	17:02		17:06	17:12	17:22	17:34	17:40	17:53
22W	K		17:24		17:33	17:38	17:44	17:52	18:04	18:10	18:23
23W	P		17:56	18:03		18:07	18:12	18:21	18:34	18:40	18:53
24W	K		18:24		18:33	18:37	18:42	18:51	19:04	19:10	19:23
25W	P		18:54	19:01		19:05	19:10	19:19	19:34	19:40	19:53
-	-	-	-	-	-	-	-	-	-	-	-
26W	K		19:54		20:03	20:07	20:12	20:21	20:34	20:40	20:53
27W	P		20:54	21:01		21:05	21:10	21:19	21:34	21:40	21:53
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

BLOCK SUMMARY RECAP

Route #: 110 - Saturday

Date: xx/xx/xx

Scheduler:

Special Instructions:

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
1								
						Total		

Block No.	START/END OF REVENUE TIME																			Revenue Hours
	4a	5a	6a	7a	8a	9a	10a	11a	12p	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	
	Early AM		AM Peak			Base (Midday)						School		PM Peak			Evening			Night	
1																					
Block No.	START/END OF REVENUE TIME																				
	4a	5a	6a	7a	8a	9a	10a	11a	12p	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	

Route 110 Saturday blocks

CHAPTER 3: EXERCISE ANSWER SHEET

Route 110 Saturday Master Schedule
Blocked

Block	Trip		Lv		Arr	Lv					Arr	Trip		Lv	Lv				Arr	Lv		Arr
	#	Via	DVC	CLD	CON	CON	CLT	CLA	CKP	MYV	WAS	#	Via	MCC	WAS	MYV	CKP	CLA	CLT	CON	CON	FRY	DVC
1	-	-	-	-	-	-	-	-	-	-	-	1W	P		6:54	7:01		7:05	7:10	7:19	7:34	7:40	7:53
2	1E	P		Into Service		6:55	7:03	7:08		7:12	7:19	2W	K		7:24		7:33	7:37	7:42	7:51	8:04	8:10	8:23
3	2E	K		Into Service		7:25	7:33	7:38	7:42		7:50	3W	P		7:54	8:01		8:05	8:10	8:19	8:34	8:40	8:53
4	3E	P		Into Service		7:55	8:03	8:08		8:12	8:19	4W	K		8:24		8:33	8:37	8:42	8:51	9:04	9:10	9:23
1	4E	K	7:58	8:09	8:15	8:25	8:33	8:38	8:42		8:50	5W	P		8:54	9:01		9:05	9:10	9:19	9:34	9:40	9:53
2	5E	P	8:28	8:39	8:45	8:55	9:03	9:08		9:12	9:19	6W	K		9:24		9:33	9:37	9:42	9:51	10:04	10:10	10:23
3	6E	K	8:58	9:09	9:15	9:25	9:33	9:38	9:42		9:50	7W	P		9:54	10:01		10:05	10:10	10:19	10:34	10:40	10:53
4	7E	P	9:28	9:39	9:45	9:55	10:03	10:08		10:12	10:19	8W	K		10:24		10:33	10:37	10:42	10:51	11:04	11:10	11:23
1	8E	K	9:58	10:09	10:15	10:25	10:33	10:38	10:42		10:50	9W	P		10:54	11:01		11:05	11:10	11:19	11:34	11:40	11:53
2	9E	P	10:28	10:39	10:45	10:55	11:03	11:08		11:12	11:19	10W	K		11:24		11:33	11:37	11:42	11:51	12:04	12:10	12:23
3	10E	K	10:58	11:09	11:15	11:25	11:33	11:38	11:42		11:50	11W	P		11:54	12:01		12:05	12:10	12:19	12:34	12:40	12:53
4	11E	P	11:28	11:39	11:45	11:55	12:03	12:08		12:12	12:19	12W	K		12:24		12:33	12:37	12:42	12:51	13:04	13:10	13:23
1	12E	K	11:58	12:09	12:15	12:25	12:33	12:38	12:42		12:50	13W	P		12:54	13:01		13:05	13:10	13:19	13:34	13:40	13:53
2	13E	P	12:28	12:39	12:45	12:55	13:03	13:08		13:12	13:19	14W	K		13:24		13:33	13:37	13:42	13:51	14:04	14:10	14:23
3	14E	K	12:58	13:09	13:15	13:25	13:33	13:38	13:42		13:50	15W	P		13:54	14:01		14:05	14:10	14:19	14:34	14:40	14:53
4	15E	P	13:28	13:39	13:45	13:55	14:03	14:08		14:12	14:19	16W	K		14:24		14:33	14:37	14:42	14:51	15:04	15:10	15:23
1	16E	K	13:58	14:09	14:15	14:25	14:33	14:38	14:42		14:50	17W	P		14:54	15:01		15:05	15:11	15:21	15:34	15:40	15:53
2	17E	P	14:28	14:39	14:45	14:53	15:03	15:10		15:15	15:23	18W	K		15:23		15:32	15:37	15:43	15:53	16:04	16:10	16:23
3	18E	K	14:57	15:08	15:16	15:23	15:33	15:40	15:45		15:55	19W	P		15:55	16:02		16:06	16:12	16:22	16:34	16:40	16:53
4	19E	P	15:25	15:38	15:46	15:53	16:03	16:10		16:15	16:23	20W	K		16:23		16:32	16:37	16:43	16:53	17:04	17:10	17:23
1	20E	K	15:55	16:08	16:16	16:23	16:33	16:40	16:45		16:55	21W	P		16:55	17:02		17:06	17:12	17:22	17:34	17:40	17:53
2	21E	P	16:25	16:38	16:46	16:54	17:04	17:11		17:16	17:24	22W	K		17:24		17:33	17:38	17:44	17:52	18:04	18:10	18:23
3	22E	K	16:55	17:08	17:16	17:24	17:34	17:41	17:46		17:56	23W	P		17:56	18:03		18:07	18:12	18:21	18:34	18:40	18:53
4	23E	P	17:25	17:38	17:46	17:54	18:04	18:11		18:16	18:24	24W	K		18:24		18:33	18:37	18:42	18:51	19:04	19:10	19:23
1	24E	K	17:58	18:09	18:15	18:25	18:33	18:38	18:42		18:50	25W	P		18:54	19:01		19:05	19:10	19:19	19:34	19:40	19:53
2	25E	P	18:28	18:39	18:45	18:55	19:03	19:08		19:12	19:19	-	-	-	-	-	-	-	-	-	-	-	-
3	26E	K	18:58	19:09	19:15	19:25	19:33	19:38	19:42		19:50	26W	K		19:54		20:03	20:07	20:12	20:21	20:34	20:40	20:53
1	27E	P	19:58	20:09	20:15	20:25	20:33	20:38		20:42	20:49	27W	P		20:54	21:01		21:05	21:10	21:19	21:34	21:40	21:53
3	28E	K	20:58	21:09	21:15	21:25	21:33	21:38	21:42		21:50	-	-	-	-	-	-	-	-	-	-	-	-
1	29E	P	21:58	22:09	22:15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

BLOCK SUMMARY RECAP

Route #: 110 - Saturday

Special Instructions:

Date: xx/xx/xx

Scheduler:

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
1	6:32A	WAS	6:54A	10:15P	CON	10:22P	15:21	15:50
2	6:48A	CON	6:55A	7:19P	WAS	7:39P	12:24	12:51
3	7:18A	CON	7:25A	9:50P	WAS	10:10P	14:25	14:52
4	7:48A	CON	7:55A	7:23P	DVC	7:35P	11:28	11:47
						Total	53:38	55:20

Additional Deadhead Allowances for Route 110 Saturday: To WAS :22

From WAS :20

Block No.	START/END OF REVENUE TIME																			Revenue Hours
	4a	5a	6a	7a	8a	9a	10a	11a	12p	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	
	Early AM		AM Peak			Base (Midday)						School		PM Peak			Evening			Night	
1			654a																1015p		15:21
2			655a													719p					12:24
3			725a															950p			14:25
4			755a													723p					11:28
Block No.						START/END OF REVENUE TIME															53:38
	4a	5a	6a	7a	8a	9a	10a	11a	12p	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	

Route 110 Saturday blocks

Notes:

CHAPTER 4

RUNCUTTING

Advanced Section

I. Introduction

This unit on runcutting will demonstrate several of the complexities involved in "cutting" vehicle blocks into assignments for operators, called "runs." For demonstration purposes, runcutting alternatives in this chapter will be developed from Route 110 and Route 32 blocks developed in Chapter 3.

II. Runcutting - An Overview

A. What is runcutting?

Runcutting is the process of developing operator assignments [runs] from a pool of vehicle blocks. Runcutting is often an iterative process. A series of changes to both blocks and runs may be necessary before "optimum" runs can be derived. Runs may consist of one or more complete or partial blocks.

During runcutting, blocks are arranged [cut] in such a way as to create straight runs and split runs. A straight run generally consists of a single block piece of approximately 8 to 10 hours of continuous work. There are instances when straight runs are developed using two block pieces that may be joined by a short [usually less than 60 minutes] paid break.

A split run generally consists of two [sometimes three] block pieces with unpaid break time (often called swing time) between the pieces. The operator is considered "off duty" during the swing periods.

B. Why is runcutting important?

Whereas cost efficient blocking is important in terms of minimizing the number of vehicles necessary to operate a given level of service, runcutting is considered a critical factor in determining the number of operators needed to operate a given level of service in the most cost efficient manner. The challenge for the scheduler is to assign all of the block pieces to the fewest number of operator runs while adhering to all relevant work rules and policy guidelines.

C. Setting up the runcutting process

Before runcutting begins, it is desirable for the scheduler to again review all relevant data and develop a comfortable understanding of the relationship among the various forms, data, objectives, and work rules. A scheduler's "street sense" of the routings, terminal locations and relief points also makes the job smoother.

At this agency, the scheduler has assembled Routes 110 and 32 master schedules, a combined block graph and a combined block summary recap. These are shown on the following pages and will be used in the runcutting examples.

It may also be noted that universal scheduling forms do not exist and that all agencies do not perform runcuts in the same manner. An agency may use a variety of scheduling forms, even for the same purpose. For example, this agency has used two different master schedule formats for Route 32 and Route 110. Part of the art of scheduling is the development of forms that are useful not only for the scheduling process, but for other departmental functions as well, such as Payroll, Maintenance and Marketing.

1) The Master Schedule

The **master schedule** provides detailed trip information by direction. It generally includes time points (including all termini and relief points), pull-on and pull-off times and locations and the times and locations of route relief points.

On Route 32, vehicles pull-out and pull-in from either of the two terminus points, CBS and RGM. On-street reliefs are also permitted at either terminus. For Route 110, the on-street relief points include the Concord Rail Station (CON) and DVC – the same points where vehicles pull on and pull off. Relief points are often shown in bold or noted in parentheses on the master schedules.

Arrival times, rather than departure times are typically used for on-street reliefs. This allows the relieving operator time to board the vehicle, set the seat and mirrors, input data into the farebox and/or perform other duties before departing the location.

Route 32 and Route 110 master schedules are shown on pages 5, 6 and 7.

2) The Block Graph

The **block graph** provides a visual overview of the blocks to be runcut. This visual representation can assist the scheduler in a number of ways, including helping determine the number and timing of on-street reliefs, calculating revenue service time for each block and pinpointing blocks that may be undesirable for runcuts. This form is also useful for penciling in potential alternative block combinations prior to establishing the final runs. Colored pencils are a useful tool when diagraming the various alternatives.

Undesirable blocks would include short blocks and blocks that start or end outside an optimum range for run type. The block graph can be helpful when looking for opportunities to combine blocks in order to reduce the number of vehicles required. Since scheduling is an iterative process, it is not uncommon for blocks to change several times during the runcutting process before the runcuts are "finalized."

The block graph for Routes 110 and 32 is shown on page 98.

3) The Block Summary Recap

The **block summary recap** primarily displays information about block pull-on and pull-off locations and times. While the block graph is especially useful as a visual aid for identifying block adjustment options, the block summary recap is particularly useful for noting run assignment and identifying block pieces that could form split runs after any block adjustments are made.

The block summary recap is shown on page 99.

Block #	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
32-01								6:10	6:17	6:27	6:32	6:40	6:50
32-02								6:40	6:47	6:57	7:03	7:10	7:20
32-03	6:26	6:36	6:43	6:49	6:58	7:05	A	7:10	7:17	7:27	7:33	7:40	7:50
32-01	6:56	7:06	7:13	7:19	7:28	7:35	M	7:40	7:47	7:57	8:03	8:10	8:20
32-02	7:26	7:36	7:43	7:49	7:58	8:05		8:10	8:17	8:27	8:33	8:40	8:50
32-03	7:56	8:06	8:13	8:19	8:28	8:35		8:40	8:47	8:57	9:03	9:10	9:20
32-01	8:26	8:36	8:43	8:49	8:58	9:05		9:10	9:17	9:27	9:33	9:40	9:50
32-02	8:56	9:06	9:13	9:19	9:28	9:35		9:40	9:47	9:57	10:03	10:10	10:20
32-03	9:26	9:36	9:43	9:49	9:58	10:05							
32-01	9:56	10:06	10:13	10:19	10:28	10:35		10:40	10:47	10:57	11:01	11:07	11:16
32-02	10:26	10:35	10:41	10:45	10:55	11:02		11:40	11:47	11:57	12:01	12:07	12:15
32-01	11:26	11:35	11:41	11:45	11:55	12:02		12:40	12:47	12:57	1:01	1:07	1:16
32-02	12:26	12:35	12:41	12:45	12:55	1:02		1:40	1:47	1:58	2:04	2:10	2:20
32-01	1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50
32-04	1:56	2:06	2:12	2:19	2:28	2:36	P	2:40	2:47	2:58	3:04	3:10	3:20
32-02	2:26	2:36	2:42	2:49	2:58	3:06	M	3:10	3:17	3:28	3:34	3:40	3:50
32-01	2:56	3:06	3:12	3:19	3:28	3:36		3:40	3:47	3:58	4:04	4:10	4:20
32-04	3:26	3:36	3:42	3:49	3:58	4:06		4:10	4:17	4:28	4:34	4:40	4:50
32-02	3:56	4:06	4:12	4:19	4:28	4:36		4:40	4:47	4:58	5:04	5;10	5:20
32-01	4:26	4:36	4:42	4:49	4:58	5:06		5:10	5:17	5:28	5:34	5:40	5:50
32-04	4:56	5:06	5:12	5:19	5:28	5:36							
32-02	5:26	5:36	5:42	5:49	5:58	6:06							
32-01	5:56	6:06	6:12	6:19	6:28	6:36							

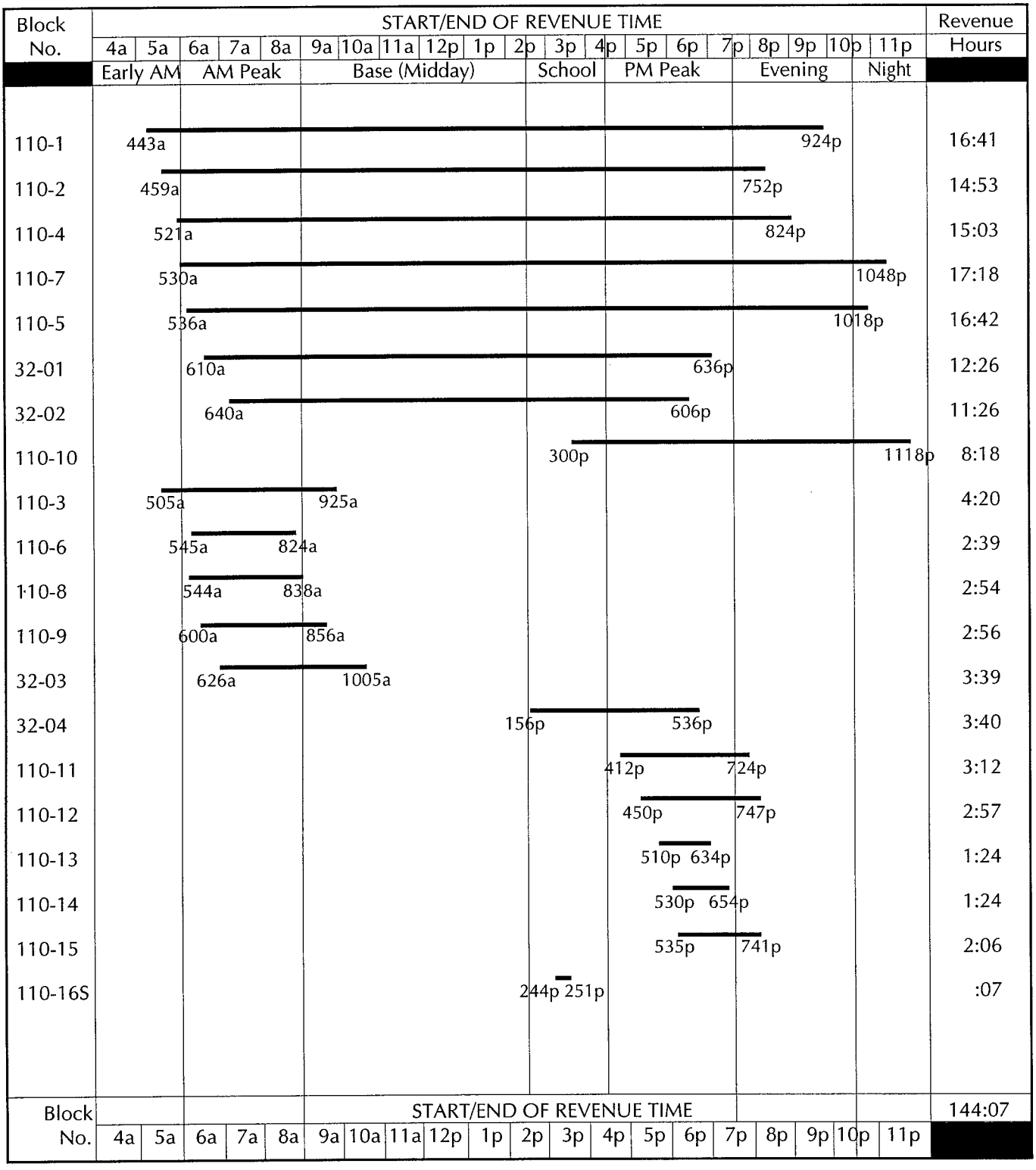
Master schedule for Route 32

Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
1W	110-1	K		5:04		5:13	5:17	5:22	5:30	5:33	5:38	5:49
2W	110-2	P		5:21	5:28		5:32	5:37	5:45	5:48	5:53	6:04
3W	110-3	K		5:31		5:40	5:45	5:51	6:00	6:03	6:09	6:21
4W	110-4	M	5:43	5:57			6:00	6:06	6:15	6:18	6:24	6:36
5W	110-5	P		6:02	6:10		6:15	6:21	6:30	6:33	6:39	6:51
6W	110-6	K		6:11		6:20	6:25	6:31	6:40	6:43	6:49	7:01
7W	110-7	M	6:18	6:32			6:35	6:41	6:50	6:55	7:01	7:13
8W	110-8	P		6:32	6:40		6:45	6:51	7:00	7:05	7:11	7:23
9W	110-1	K		6:41		6:50	6:55	7:01	7:10	7:15	7:21	7:33
10W	110-9	M	6:48	7:02			7:05	7:11	7:20	7:25	7:31	7:43
11W	110-2	P		7:02	7:10		7:15	7:21	7:30	7:35	7:41	7:53
12W	110-3	K		7:11		7:20	7:25	7:31	7:40	7:45	7:51	8:03
13W	110-4	M	7:24	7:38			7:41	7:46	7:55	8:00	8:06	8:18
14W	110-5	P		7:39	7:47		7:52	7:58	8:07	8:15	8:21	8:34
15W	110-6	K		7:55		8:04	8:09	8:15	8:24	Out of Service		
16W	110-7	M	8:00	8:14			8:17	8:23	8:32	8:35	8:41	8:54
17W	110-8	P		8:09	8:17		8:23	8:29	8:38	Out of Service		
18W	110-1	P		8:14	8:21		8:27	8:33	8:42	8:55	9:01	9:14
19W	110-9	K		8:29		8:38	8:42	8:47	8:56	Out of Service		
20W	110-2	M	8:40	8:54			8:57	9:02	9:11	9:13	9:19	9:32
21W	110-3	P		9:00	9:07		9:11	9:16	9:25	Out of Service		
22W	110-4	K		9:11		9:20	9:24	9:29	9:38	9:40	9:46	9:59
23W	110-5	M	9:29	9:41			9:44	9:49	9:58	10:00	10:06	10:19
24W	110-7	P		9:53	10:00		10:04	10:09	10:18	10:20	10:26	10:39
25W	110-1	K		10:11		10:20	10:24	10:29	10:38	10:40	10:46	10:59
26W	110-2	M	10:29	10:41			10:44	10:49	10:58	11:00	11:06	11:19
27W	110-4	P		10:52	10:59		11:03	11:09	11:18	11:20	11:25	11:37
28W	110-5	K		11:10		11:19	11:23	11:29	11:38	11:40	11:45	11:57
29W	110-7	M	11:29	11:40			11:43	11:49	11:58	12:00	12:05	12:17
30W	110-1	P		11:52	11:59		12:03	12:09	12:18	12:20	12:25	12:37
31W	110-2	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
32W	110-4	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
33W	110-5	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
34W	110-7	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
35W	110-1	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
36W	110-2	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
37W	110-4	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
38W	110-5	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
39W	110-16S	K		2:44S		2:51S						
40W	110-7	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
41W	110-1	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
42W	110-2	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
43W	110-4	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
44W	110-10	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
45W	110-5	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
46W	110-11	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
47W	110-7	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
48W	110-15	--								5:35	5:41	5:54
49W	110-1	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
50W	110-12	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14
51W	110-2	K		5:33		5:42	5:47	5:53	6:03	6:05	6:11	6:24
52W	110-13	M	5:45	5:53			5:57	6:03	6:13	6:15	6:21	6:34
53W	110-4	P		5:55	6:03		6:07	6:13	6:23	6:25	6:31	6:44
54W	110-14	K		6:03		6:12	6:17	6:23	6:33	6:35	6:41	6:54
55W	110-10	M	6:15	6:23			6:27	6:33	6:43	6:45	6:51	7:04
56W	110-5	P		6:25	6:33		6:37	6:43	6:53	6:55	7:01	7:14
57W	110-11	K		6:33		6:42	6:47	6:53	7:03	7:05	7:11	7:24
58W	110-7	M	6:45	6:53			6:57	7:03	7:11	7:15	7:20	7:31
59W	110-15	P		6:55	7:03		7:07	7:13	7:21	7:25	7:30	7:41
60W	110-1	K		7:07		7:15	7:19	7:24	7:32	Out of Service		
61W	110-12	M	7:23	7:31			7:34	7:39	7:47	7:50	7:55	8:06
62W	110-2	P		7:28	7:35		7:39	7:44	7:52	Out of Service		
63W	110-4	K		7:42		7:50	7:54	7:59	8:07	8:10	8:15	8:26
64W	110-10	M	8:00	8:08			8:11	8:16	8:24	Out of Service		
65W	110-11	P		8:14	8:21		8:25	8:30	8:38	8:40	8:45	8:56
66W	110-15	K		8:37		8:45	8:49	8:53	9:01	9:10	9:15	9:26
67W	110-12	M	9:00	9:08			9:11	9:16	9:24	Out of Service		
68W	110-4	P		9:24	9:31		9:35	9:40	9:48	9:50	9:55	10:06
69W	110-11	K		9:53		10:01	10:05	10:10	10:18	Out of Service		
70W	110-15	P		10:24	10:31		10:35	10:40	10:48	Out of Service		
71W	110-4	K		10:53		11:01	11:05	11:10	11:18	Out of Service		

Master schedule for Route 110 WESTbound

Trip #	Block #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
1E	110-1	P				4:43	4:49	4:53		4:57	5:04	
2E	110-2	K				4:59	5:05	5:09	5:13		5:21	
3E	110-3	P				5:05	5:11	5:15		5:19	5:27	
4E	110-4	M				5:21	5:27	5:31			5:34	5:42
5E	110-5	K				5:36	5:44	5:49	5:53		6:02	
6E	110-6	P				5:45	5:53	5:58		6:03	6:11	
7E	110-7	M	5:30	5:40	5:46	5:52	6:00	6:05			6:09	6:17
8E	110-8	K	5:44	5:55	6:02	6:06	6:14	6:19	6:23		6:32	
9E	110-1	P	5:54	6:05	6:12	6:15	6:23	6:28		6:33	6:41	
10E	110-9	M	6:00	6:11	6:18	6:22	6:30	6:35			6:39	6:47
11E	110-2	K	6:14	6:25	6:32	6:36	6:44	6:49	6:53		7:02	
12E	110-3	P	6:23	6:34	6:41	6:45	6:53	6:58		7:03	7:11	
13E	110-4	M	6:38	6:49	6:56	6:58	7:06	7:11			7:15	7:23
14E	110-5	K	6:53	7:04	7:11	7:13	7:21	7:26	7:30		7:39	
15E	110-6	P	7:08	7:19	7:26	7:29	7:37	7:42		7:47	7:55	
16E	110-7	M	7:14	7:25	7:32	7:34	7:42	7:47			7:47	7:55
17E	110-8	K	7:24	7:35	7:42	7:43	7:51	7:56	8:00		8:09	
18E	110-1	K	7:34	7:45	7:52	7:53	8:00	8:04	8:07		8:14	
19E	110-9	P	7:44	7:55	8:02	8:04	8:12	8:17		8:22	8:29	
20E	110-2	M	7:55	8:06	8:13	8:15	8:23	8:28			8:32	8:40
21E	110-3	K	8:10	8:21	8:28	8:30	8:38	8:43	8:47		8:55	
22E	110-4	P	8:25	8:36	8:43	8:45	8:53	8:58		9:02	9:09	
23E	110-5	M	8:45	8:56	9:03	9:05	9:13	9:18			9:21	9:29
24E	110-7	K	9:05	9:16	9:23	9:25	9:33	9:38	9:42		9:50	
25E	110-1	P	9:25	9:36	9:43	9:45	9:53	9:58		10:02	10:09	
26E	110-2	M	9:45	9:56	10:03	10:05	10:13	10:18			10:21	10:29
27E	110-4	K	10:05	10:16	10:22	10:25	10:38	10:42	10:42		10:50	
28E	110-5	P	10:25	10:36	10:42	10:45	10:53	10:58		11:02	11:09	
29E	110-7	M	10:45	10:56	11:02	11:05	11:13	11:18			11:21	11:29
30E	110-1	K	11:05	11:16	11:22	11:25	11:33	11:38	11:42		11:50	
31E	110-2	P	11:25	11:36	11:42	11:45	11:53	11:58		12:02	12:09	
32E	110-4	M	11:45	11:56	12:02	12:05	12:13	12:18			12:21	12:29
33E	110-5	K	12:05	12:16	12:22	12:25	12:33	12:38	12:42		12:49	
34E	110-7	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	
35E	110-1	M	12:45	12:56	1:02	1:05	1:13	1:18			1:21	1:29
36E	110-2	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	110-4	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	110-5	M	1:45	1:56	2:02	2:05	2:13	2:18			2:21	2:29
39E	110-7	K	2:01	2:14	2:21	2:24	2:33	2:39	2:44		2:54	
40E	110-1	P	2:20	2:33	2:40	2:43	2:52	2:58		3:03	3:12	
41E	110-2	M	2:40	2:53	3:00	3:03	3:12	3:18			3:22	3:36
42E	110-4	K	3:00	3:13	3:20	3:24	3:33	3:39	3:44		3:54	
43E	110-10	P	3:20	3:33	3:40	3:44	3:53	3:59		4:04	4:13	
44E	110-5	M	3:40	3:53	4:00	4:02	4:11	4:17			4:21	4:35
45E	110-11	K				4:12	4:22	4:29	4:34		4:44	
46E	110-7	P	3:55	4:08	4:16	4:20	4:30	4:37		4:42	4:50	
47E	110-1	M	4:15	4:28	4:36	4:40	4:50	4:57			5:00	5:14
48E	110-12	K				4:50	5:00	5:07	5:12		5:22	
49E	110-2	P	4:35	4:48	4:56	5:00	5:10	5:17		5:22	5:30	
50E	110-13	M				5:10	5:20	5:27			5:30	5:44
51E	110-4	K	4:55	5:08	5:16	5:20	5:30	5:37	5:42		5:52	
52E	110-14	P				5:30	5:40	5:47		5:52	6:00	
53E	110-10	M	5:15	5:28	5:36	5:40	5:50	5:57			6:00	6:14
54E	110-5	K	5:25	5:38	5:46	5:50	6:00	6:07	6:12		6:22	
55E	110-11	P	5:35	5:48	5:56	6:00	6:10	6:17		6:22	6:30	
56E	110-7	M	5:45	5:58	6:00	6:10	6:20	6:27			6:30	6:44
57E	110-15	K	5:55	6:08	6:16	6:20	6:30	6:37	6:42		6:52	
58E	110-1	P	6:05	6:18	6:26	6:30	6:40	6:47		6:52	7:00	
59E	110-12	M	6:20	6:33	6:41	6:45	6:55	7:02			7:05	7:17
60E	110-2	P	6:35	6:48	6:56	7:00	7:07	7:12	7:16		7:24	
61E	110-4	K	6:50	7:03	7:11	7:15	7:22	7:27		7:31	7:38	
62E	110-10	M	7:10	7:21	7:27	7:30	7:37	7:42			7:45	7:57
63E	110-11	K	7:30	7:41	7:47	7:50	7:57	8:02	8:06		8:14	
64E	110-15	P	7:50	8:01	8:07	8:10	8:17	8:22		8:26	8:33	
65E	110-12	M	8:10	8:21	8:27	8:30	8:37	8:42			8:45	8:57
66E	110-4	K	8:40	8:51	8:57	9:00	9:07	9:12	9:16		9:24	
67E	110-11	P	9:10	9:21	9:27	9:30	9:37	9:42		9:46	9:53	
68E	110-15	K	9:40	9:51	9:57	10:00	10:07	10:12	10:16		10:24	
69E	110-4	P	10:10	10:21	10:27	10:30	10:37	10:42		10:46	10:53	

Master schedule for Route 110 EASTbound



Block graph for Route 32 and Route 110

Route #: 110
Route#: 32
Date: xx/xx/xx
Scheduler:

BLOCK SUMMARY RECAP

Special Instructions:

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-1	4:36A	CON	4:43A	9:24P	CON	9:31P	16:41	16:55
110-2	4:52A	CON	4:59A	7:52P	CON	7:59P	14:53	15:07
110-3	4:58A	CON	5:05A	9:25A	CON	9:32A	4:20	4:34
110-4	5:14A	CON	5:21A	8:24P	CON	8:31P	15:03	15:17
110-5	5:29A	CON	5:36A	10:18P	CON	10:25P	16:42	16:56
110-6	5:38A	CON	5:45A	8:24A	CON	8:31A	2:39	2:53
110-7	5:18A	DVC	5:30A	10:48P	CON	10:55P	17:18	17:37
110-8	5:32A	DVC	5:44A	8:38A	CON	8:45A	2:54	3:13
110-9	5:48A	DVC	6:00A	8:56A	CON	9:03A	2:56	3:15
110-10	2:48P	DVC	3:00P	11:18P	CON	11:25P	8:18	8:37
110-11	4:05P	CON	4:12P	7:24P	DVC	7:36P	3:12	3:31
110-12	4:43P	CON	4:50P	7:47P	CON	7:54P	2:57	3:11
110-13	5:03P	CON	5:10P	6:34P	DVC	6:46P	1:24	1:43
110-14	5:23P	CON	5:30P	6:54P	DVC	7:06P	1:24	1:43
110-15	5:28P	CON	5:35P	7:41P	DVC	7:53P	2:06	2:25
110-16S	2:09P	WAS	2:44P	2:51P	CKP	3:16P	:07	1:07
32-01	6:00A	RGM	6:10A	6:36P	RGM	6:46P	12:26	12:46
32-02	6:30A	RGM	6:40A	6:06P	RGM	6:16P	11:26	11:46
32-03	6:16A	CBS	6:26A	10:05A	RGM	10:15A	3:39	3:59
32-04	1:46P	CBS	1:56P	5:36P	RGM	5:46P	3:40	4:00
						Total	144:07	150:35

Block summary recap for Route 32 and Route 110

III. Work Rules

Work rules are many and varied among transit agencies. It is extremely important that the scheduler be knowledgeable of all applicable agency work rules. For demonstration purposes, the following work rules will apply to the runcutting process demonstrated in this chapter:

- Minimum and Maximum Platform Time
- Report and Turn-in Allowances
- Spread Time and Spread Penalty
- On-street Relief Allowances
- Make-up Percentages
- Run Type Percentages
- Part-time Operator Runs

A. Minimum and maximum platform time

This work rule defines the minimum and maximum size a run can be as measured by *platform time*. Platform time is the total time during which an operator is behind the wheel of a vehicle in both revenue and nonrevenue service. For Routes 32 and 110, minimum platform time for a legal full-time run is established at 6 hours and maximum platform time is 9 hours.

When block pieces cannot be assembled into runs of minimum platform time, other options can be considered, depending on agency work rules. For example, those blocks may be assigned to the Extra Board (a pool of standby on-duty operators) or arranged into runs for part-time operators.

B. Report and turn-in Allowances

The *report allowance* is an amount of time paid to an operator starting at the time the operator is to report for duty (report time) and ending at the time the operator is scheduled to pull-out. This is paid time for the operator to get ready for revenue service and can include duties such as gathering supplies, receiving instructions, locating the assigned vehicle and performing a pre-trip inspection.

A 10-minute report allowance will be granted for all reports at the garage. For reports associated with an on-street relief, a 5-minute report allowance will be granted.

The *turn-in allowance* is time paid to an operator for reporting to the dispatcher at the conclusion of the run, turning in transfers, fare media or other supplies and reports or other end of run duties. A one time 5-minute turn-in allowance will be granted for each run. For split runs, the turn-in allowance will be associated with the last piece of work.

C. Spread time and spread penalty

For a run, *spread time* is defined as the total elapsed time between the first report time and the final turn-in time. A spread maximum typically applies to split runs and, depending on the agency, varies between 10 and 15 hours in duration. For Routes 32 and 110, the maximum allowed spread will be 14.5 hours. There will be no limit or cap on the number of system-wide split runs that can exist within specified spread interval limits.

A *spread penalty* is payment to an operator for time worked beyond spread time limits. Some transit systems are subject to a multilayer spread penalty with the penalty ranging from one-half time to full-time pay for various levels of excess minutes.

For Routes 32 and 110 full-time runs, the spread penalty will be one-half of all minutes over a 12-hour spread (13 for part-time runs) paid at straight time. Overtime will not be paid when spread minutes are paid.

D. On-street relief allowance

A *relief allowance* is a payment to operators who are required to travel from the garage to the relief location (and/or vise versa). For Routes 32 and 110, the relief allowance will consist of the deadhead time (the commute time between the garage and the relief point) plus one-half of the headway at the time of the relief. This will apply to both the relieving and relieved run.

E. Make-up allowance

A *make-up allowance* is payment for the difference in time actually worked and any minimum daily or weekly guarantee. For example, a run that totals 7:50 platform and allowances will be granted 10 minutes of make-up time so that the total work hours equals an 8-hour minimum daily guarantee. At this agency, a daily guarantee of 8 hours for full-time runs is incorporated in the work rules. There is no guarantee for part-time runs.

F. Run type percentages

Many agencies are required to develop a certain percentage of straight runs or to restrict the number of split runs. A typical *run type percentage* stipulation requires that one-half of all runs must be straight runs while one-third of the remaining split runs must not exceed a 12-hour spread, one-third may not exceed a 12.5-hour spread and the rest may not exceed a 13-hour spread.

For Routes 32 and 110, one-half of all full-time runs must be straight. Of the remaining runs, none can exceed 14.5 hours of spread time.

G. Part-time operator runs

Work rules at this agency restrict the number of part-time runs (runs working less than 6 hours) to a maximum of 20% of the number of full-time runs.

Work rules for Routes 32 and 110 are summarized on the following page.

H. Work rules summary

Work Rule	Stipulation
Minimum Platform Time	6 hours for a full-time run; fewer hours qualifies for a part-time run
Maximum Platform Time	9 hours
Report Allowance	10 minutes per garage report; 5 minutes for on-street relief reports. (Applies to both full- and part-time runs).
Turn-in Allowance	One 5-minute turn-in allowance per run. (Applies to both full- and part-time runs).
Spread Time	14.5 hours maximum spread. (Applies to both full- and part-time runs).
Spread Penalty	1/2 of the minutes over 12 hours @ straight time for full-time runs; 1/2 of the minutes over 13 hours @ straight time for part-time runs.
On-street Relief Allowances	Relief allowances to and from all relief points will consist of the deadhead allowance to that point plus 1/2 of the headway in effect at the time of the relief.
Make-up Allowance	Up to 8 daily pay hours for full-time runs only; no minimum guarantee for part-time runs.
Run Type Percentages	Straights - Minimum of 1/2 of all full-time runs. No cap or limit on the number of split runs within specified spread intervals.
Part-time Operators	Part-time runs (< 6 hours platform) cannot exceed 20% of full-time runs.

Summary of work rules for Route 32 and Route 110

I. Use of drop backs in runcutting

The term "drop back" can refer to either vehicles or operators. For vehicles, drop backs are small additions of running time, generally 1 to 2 minutes, on a specific trip at a specific time point or stop in order to delay the vehicle for a specific purpose. Drop backs generally occur at either a route terminal or a mid-route relief point.

Common reasons for vehicle drop backs include ensuring a timed transfer between two routes at an intersecting point and accommodating on-street reliefs.

For operators, drop backs are a method of providing mandatory meal or other types of breaks without disrupting the consistency of service (as perceived by the customer).

For example, a transit system requires a 30-minute meal break between the second and sixth hours of an 8-hour straight run. A relief operator meets the vehicle on route and continues the trip while the regular operator has a meal in a nearby restaurant. At the conclusion of the break, the relieved operator may pick up the same vehicle block (on the return trip, for instance) or be assigned to another block passing through the same terminal or relief point.

Some systems assign one operator to cover a series of consecutive meal reliefs on routes that use the same relief point. The meal reliefs may be incorporated into one piece of a split run, or in some cases, a straight run. Another option is to spread the meal reliefs over several runs, creating a "domino effect" wherein a number of operators with straight runs may, in series, work multiple routes within their work day.

IV. Looking for Blocking Efficiencies

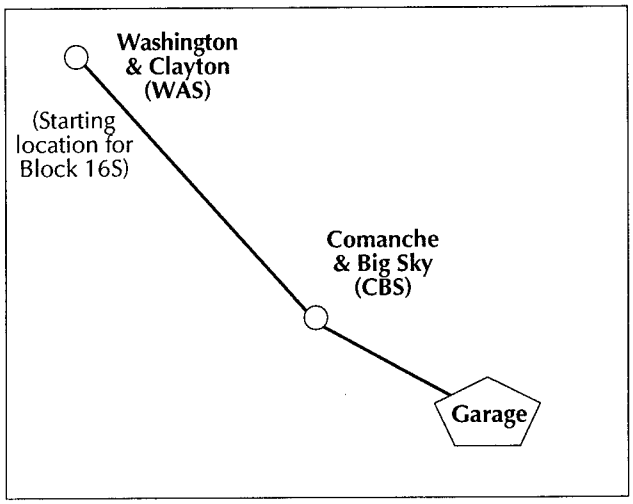
It is common for the scheduler to once again evaluate the block pool prior to runcutting. It is important to consider the availability of blocks that can be efficiently cut into runs. For example, a block piece in the 15 to 16 hour range could possibly be cut into 2 straight runs. Shorter block pieces can be evaluated to determine if rehooking can result in more efficient split runs (i.e., reduce spread time, minimize make-up allowance, etc.) without adding excessive layover.

A. Rehooking a school extra

One glaring inefficiency evident in the block graph is Block 110-16S. This block contains 1 hour and 7 minutes of platform time (see block summary recap) with only 7 minutes of revenue time.

Since it ends just before the P.M. Peak, it might be a good candidate to combine with an A.M. piece to form a split run with very little spread. However, the starting location (WAS) and ending location (CKP) for Block 110-16S are not shared by any other Route 110 block, nor are the starting time (2:44 p.m.) and ending time (2:51 p.m.) very close to any other Route 110 or Route 32 block start and end times. This means that rehooking Block 110-16S with another Route 110 block would likely incur significant deadhead and/or significant layover time.

However, the scheduler notes that a vehicle deadheading from the garage to the starting location of Block 110-16S (WAS) would pass by Comanche & Big Sky (CBS), a Route 32 terminus. This opens the possibility that a Route 32 vehicle arriving at CBS could deadhead to WAS and make the Block 110-16S trip.



The Block 110-16S pull-out route passes by CBS.

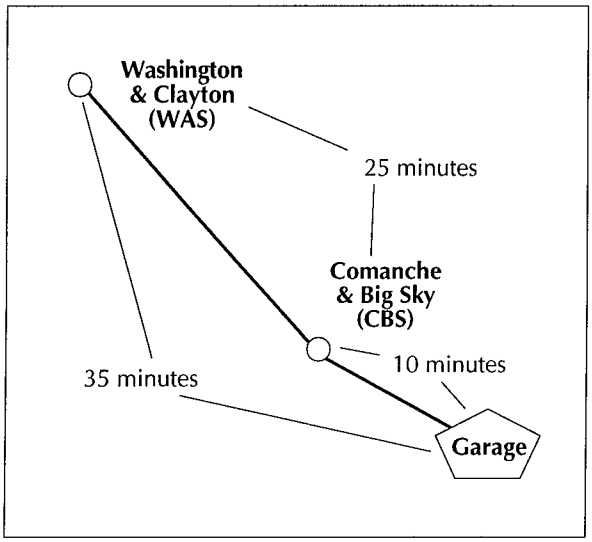
The master schedule indicates that Route 32 Block 32-02 has a trip arriving at CBS at 2:20 p.m. For this vehicle to make a trip starting at WAS at 2:44 p.m., it would need 24 minutes to deadhead from CBS to WAS (2:20 p.m. to 2:44 p.m.).

Block #	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
32-01	11:26	11:35	11:41	11:45	11:55	12:02	P	12:40	12:47	12:57	1:01	1:07	1:16
32-02	12:26	12:35	12:41	12:45	12:55	1:02	M	1:40	1:47	1:58	2:04	2:10	2:20
32-01	1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50

Route 32 has a trip arriving at CBS at 2:20 p.m.

To determine if a vehicle can deadhead from CBS to WAS in 24 minutes, the scheduler must establish that the deadhead time from CBS to WAS is around 24 minutes or less. The time to travel from CBS to WAS can be computed by subtracting the deadhead time from the garage location to WAS from the deadhead time from the garage location to CBS. Those deadhead times are available from the block summary recap form as pull-out times.

The pull-out time for Block 110-16S (garage location to WAS) is listed as 35 minutes (2:09 p.m. to 2:44 p.m.). The pull-out time listed for Block 32-03 is listed as 10 minutes (6:16 a.m. to 6:26 a.m.). The difference is 25 minutes (35 - 10).



Route #: 110
Route#: 32
Date: xx/xx/xx
Scheduler:

BLOCK SUM

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME
110-16S	2:09P	WAS	2:44P
32-03	6:16A	CBS	6:26A

Block 110-16S requires 35 Minutes of pull-out time to WAS.
Block 32-03 requires 10 Minutes pull-on time to CBS.

Although 25 minutes are technically required for this hook, the scheduler decides, based on typical traffic conditions during that time of day, that the 24 available minutes is sufficient. It is certainly close enough to justify the elimination of the inefficient block 110-16S. What would be the consequences of this rehook?

1) Inefficient Block 110-16S would no longer exist.
2) Newly rehooked Block 32-02 would have a platform time of 8:46. (6:30 a.m. to 3:16 p.m.) and a revenue service time of 8:11 (8:46 platform minus 10 minutes pull-out and 25 minutes pull-in).
3) The remaining portion of the original Block 32-02 (now numbered as 32-05) would become a separate and unique block piece, operating in revenue service from 2:26 p.m. to 6:06 p.m. with a platform time of 4:00.

Since this change can be done within the work rules and will result in a better platform to revenue service ratio, the decision is made to rehook.

This example again demonstrates the interactiveness of the scheduling process. Although the master schedules were developed and blocked earlier, the runcutting process allowed the scheduler to further evaluate the process for efficiencies. The modified master schedules, block graph and block summary recap forms appear on the following pages.

1) Revising the master schedule

Changes to the master schedule are as follows:

Block #	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky	
32-01								6:10	6:17	6:27	6:32	6:40	6:50	
32-02								6:40	6:47	6:57	7:03	7:10	7:20	
32-03	6:26	6:36	6:43	6:49	6:58	7:05	A	7:10	7:17	7:27	7:33	7:40	7:50	
32-01	6:56	7:06	7:13	7:19	7:28	7:35	M	7:40	7:47	7:57	8:03	8:10	8:20	
32-02	7:26	7:36	7:43	7:49	7:58	8:05		8:10	8:17	8:27	8:33	8:40	8:50	
32-03	7:56	8:06	8:13	8:19	8:28	8:35		8:40	8:47	8:57	9:03	9:10	9:20	
32-01	8:26	8:36	8:43	8:49	8:58	9:05		9:10	9:17	9:27	9:33	9:40	9:50	
32-02	8:56	9:06	9:13	9:19	9:28	9:35		9:40	9:47	9:57	10:03	10:10	10:20	
32-03	9:26	9:36	9:43	9:49	9:58	10:05		Out of Service						
32-01	9:56	10:06	10:13	10:19	10:28	10:35		10:40	10:47	10:57	11:01	11:07	11:16	
32-02	10:26	10:35	10:41	10:45	10:55	11:02		11:40	11:47	11:57	12:01	12:07	12:15	
32-01	11:26	11:35	11:41	11:45	11:55	12:02		12:40	12:47	12:57	1:01	1:07	1:16	
32-02	12:26	12:35	12:41	12:45	12:55	1:02		1:40	1:47	1:58	2:04	2:10	2:20	To Route 110
32-01	1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50	
32-04	1:56	2:06	2:12	2:19	2:28	2:36	P	2:40	2:47	2:58	3:04	3:10	3:20	
32-05	2:26	2:36	2:42	2:49	2:58	3:06	M	3:10	3:17	3:28	3:34	3:40	3:50	
32-01	2:56	3:06	3:12	3:19	3:28	3:36		3:40	3:47	3:58	4:04	4:10	4:20	
32-04	3:26	3:36	3:42	3:49	3:58	4:06		4:10	4:17	4:28	4:34	4:40	4:50	
32-05	3:56	4:06	4:12	4:19	4:28	4:36		4:40	4:47	4:58	5:04	5:10	5:20	
32-01	4:26	4:36	4:42	4:49	4:58	5:06		5:10	5:17	5:28	5:34	5:40	5:50	
32-04	4:56	5:06	5:12	5:19	5:28	5:36		Out of Service						
32-05	5:26	5:36	5:42	5:49	5:58	6:06		Out of Service						
32-01	5:56	6:06	6:12	6:19	6:28	6:36		Out of Service						

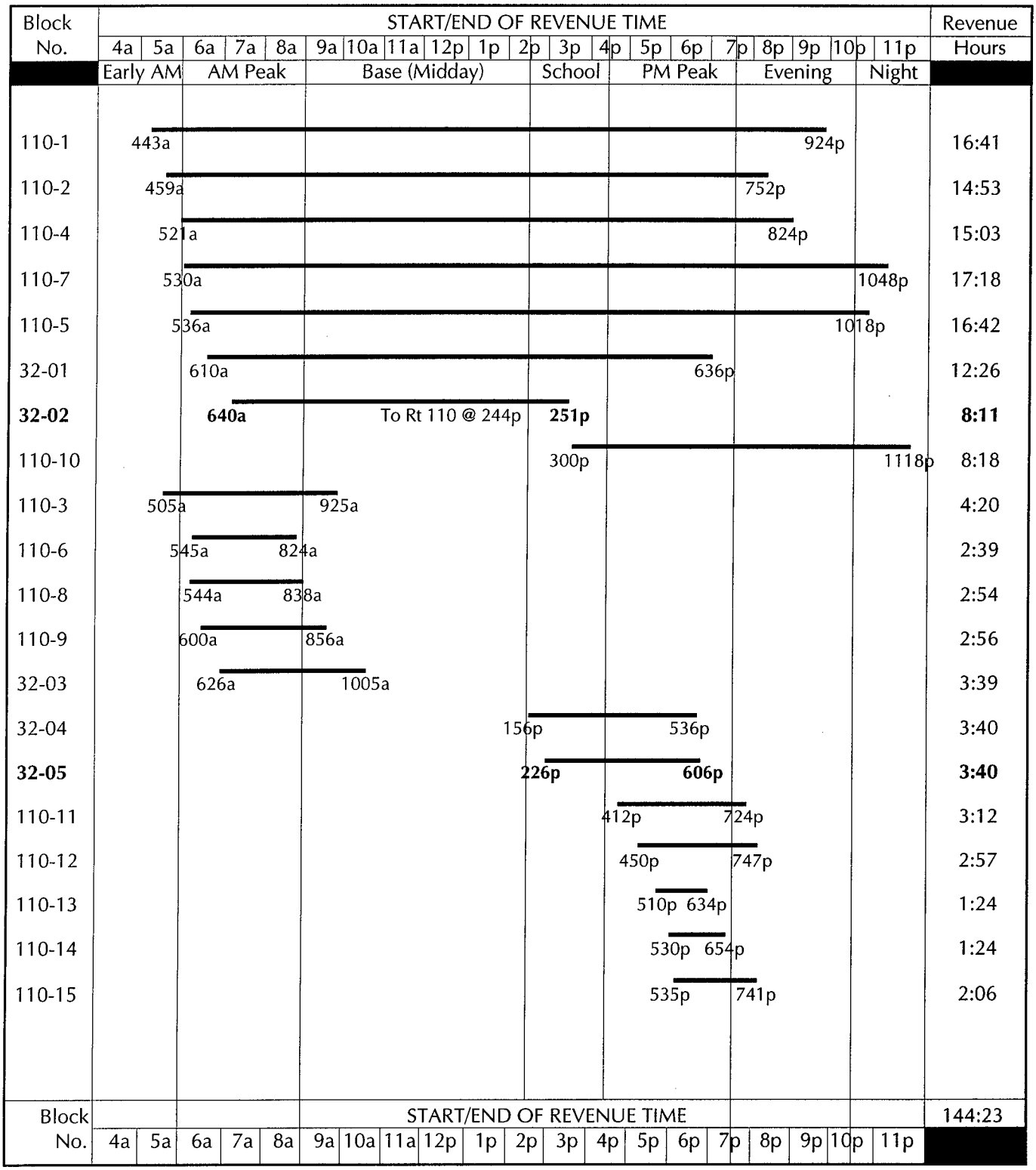
Revised master schedule for Route 32

	Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
	31W	110-2	K		12:10		12:19	12:23	12:29	12:38	12:40	12:45	12:57
	32W	110-4	M	12:29	12:40			12:43	12:49	12:58	1:00	1:05	1:17
	33W	110-5	P		12:52	12:59		1:03	1:09	1:18	1:20	1:25	1:37
	34W	110-7	K		1:10		1:19	1:23	1:29	1:38	1:40	1:45	1:57
	35W	110-1	M	1:29	1:40			1:43	1:49	1:58	2:00	2:05	2:18
	36W	110-2	P		1:52	1:59		2:03	2:09	2:18	2:20	2:25	2:38
	37W	110-4	K		2:09		2:18	2:23	2:29	2:39	2:40	2:45	2:58
	38W	110-5	M	2:32	2:40			2:43	2:49	2:59	3:04	3:09	3:22
From Rt 32	39W	**32-02**	K		2:44S		2:51S	Out of Service					
	40W	110-7	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43
	41W	110-1	K		3:12		3:21	3:26	3:32	3:42	3:47	3:52	4:05
	42W	110-2	M	3:36	3:44			3:47	3:53	4:03	4:05	4:10	4:23
	43W	110-4	P		3:54	4:03		4:07	4:13	4:23	4:25	4:30	4:43
	44W	110-10	K		4:13		4:22	4:27	4:33	4:43	4:46	4:51	5:04
	45W	110-5	M	4:36	4:44			4:47	4:53	5:03	5:05	5:10	5:23
	46W	110-11	P		4:45	4:53		4:57	5:03	5:13	5:15	5:21	5:34
	47W	110-7	K		4:50		4:59	5:04	5:10	5:20	5:25	5:31	5:44
	48W	110-15	--								5:35	5:41	5:54
	49W	110-1	M	5:15	5:23			5:27	5:33	5:43	5:45	5:51	6:04
	50W	110-12	P		5:25	5:33		5:37	5:43	5:53	5:55	6:01	6:14

Revision to master schedule for Route 110 WESTbound

2) Revising the block graph

The revisions to the block graph for Routes 32 and 110 are shown in bold below:



Revised block graph for Route 32 and Route 110

3) Revising the block summary recap

The revisions to the block summary recap for Routes 32 and 110 are shown in bold below:

Route #: 110
Route#: 32
Date: xx/xx/xx
Scheduler:

BLOCK SUMMARY RECAP
Special Instructions:

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-1	4:36A	CON	4:43A	9:24P	CON	9:31P	16:41	16:55
110-2	4:52A	CON	4:59A	7:52P	CON	7:59P	14:53	15:07
110-3	4:58A	CON	5:05A	9:25A	CON	9:32A	4:20	4:34
110-4	5:14A	CON	5:21A	8:24P	CON	8:31P	15:03	15:17
110-5	5:29A	CON	5:36A	10:18P	CON	10:25P	16:42	16:56
110-6	5:38A	CON	5:45A	8:24A	CON	8:31A	2:39	2:53
110-7	5:18A	DVC	5:30A	10:48P	CON	10:55P	17:18	17:37
110-8	5:32A	DVC	5:44A	8:38A	CON	8:45A	2:54	3:13
110-9	5:48A	DVC	6:00A	8:56A	CON	9:03A	2:56	3:15
110-10	2:48P	DVC	3:00P	11:18P	CON	11:25P	8:18	8:37
110-11	4:05P	CON	4:12P	7:24P	DVC	7:36P	3:12	3:31
110-12	4:43P	CON	4:50P	7:47P	CON	7:54P	2:57	3:11
110-13	5:03P	CON	5:10P	6:34P	DVC	6:46P	1:24	1:43
110-14	5:23P	CON	5:30P	6:54P	DVC	7:06P	1:24	1:43
110-15	5:28P	CON	5:35P	7:41P	DVC	7:53P	2:06	2:25
32-01	6:00A	RGM	6:10A	6:36P	RGM	6:46P	12:26	12:46
32-02	**6:30A**	**RGM**	**6:40A**	**2:51P**	**CKP**	**3:16P**	**8:11**	**8:46**
32-03	6:16A	CBS	6:26A	10:05A	RGM	10:15A	3:39	3:59
32-04	1:46P	CBS	1:56P	5:36P	RGM	5:46P	3:40	4:00
32-05	**2:16P**	**CBS**	**2:26P**	**6:06P**	**RGM**	**6:16P**	**3:40**	**4:00**
						Total	**144:23**	**150:28**

Revised block summary recap for Route 32 and Route 110

V. Initiating the Runcut

At this point in the process, the scheduler begins the runcut. The block graph and block summary recap forms can be utilized by the scheduler to help "sketch" information about the runcut, including estimating the number and types of runs that may result.

A. Estimating the number of runs

It is advisable to prepare an estimate of the number of runs that will result from the block pool. This estimate will aid the scheduler in determining whether the process is on target. More runs than the estimate may indicate that blocks have been used more than once. Fewer runs may indicate that some blocks have been left out.

The most commonly used estimation technique consists of dividing the total platform time contained in the blocks by the number of platform hours anticipated in each run.

For example, assuming runs of approximately 8 hours each would result in the following estimate:

Total Routes 32 & 110 Platform Hours	=	150:28
Approximate Platform Hours Per Run	=	8
Estimated Number of Runs	=	**18.81 or 19**

This estimation technique indicates that around 19 runs are to be cut, given runs in the 8-hour range.

However, there are a number of small peak period pieces in the block pool. If they are pieced together as split runs, the likelihood that they will form full-time runs (runs with a minimum of 6 hours platform time) is questionable. Therefore, additional analysis of run possibilities is desirable.

B. Analyzing run possibilities

The block graph provides a useful visual aid in further examining run possibilities. For example, 6 base blocks (blocks that typically start in the early A.M. and run continuously through the P.M. peak) exist (see next page). Five of those base blocks have the potential to cut into 2 straight runs of approximately 8 hours each. The sixth base block, 32-01, could be cut into an 8-hour straight run with a piece left over. There are 2 blocks that are of sufficient length to cut into natural straight runs without any leftover pieces. (A natural straight is a block that would constitute a legal straight run without any additional cutting.)

The scheduler has made notes on the block graph on the following page to identify these and other possible runcut combinations.

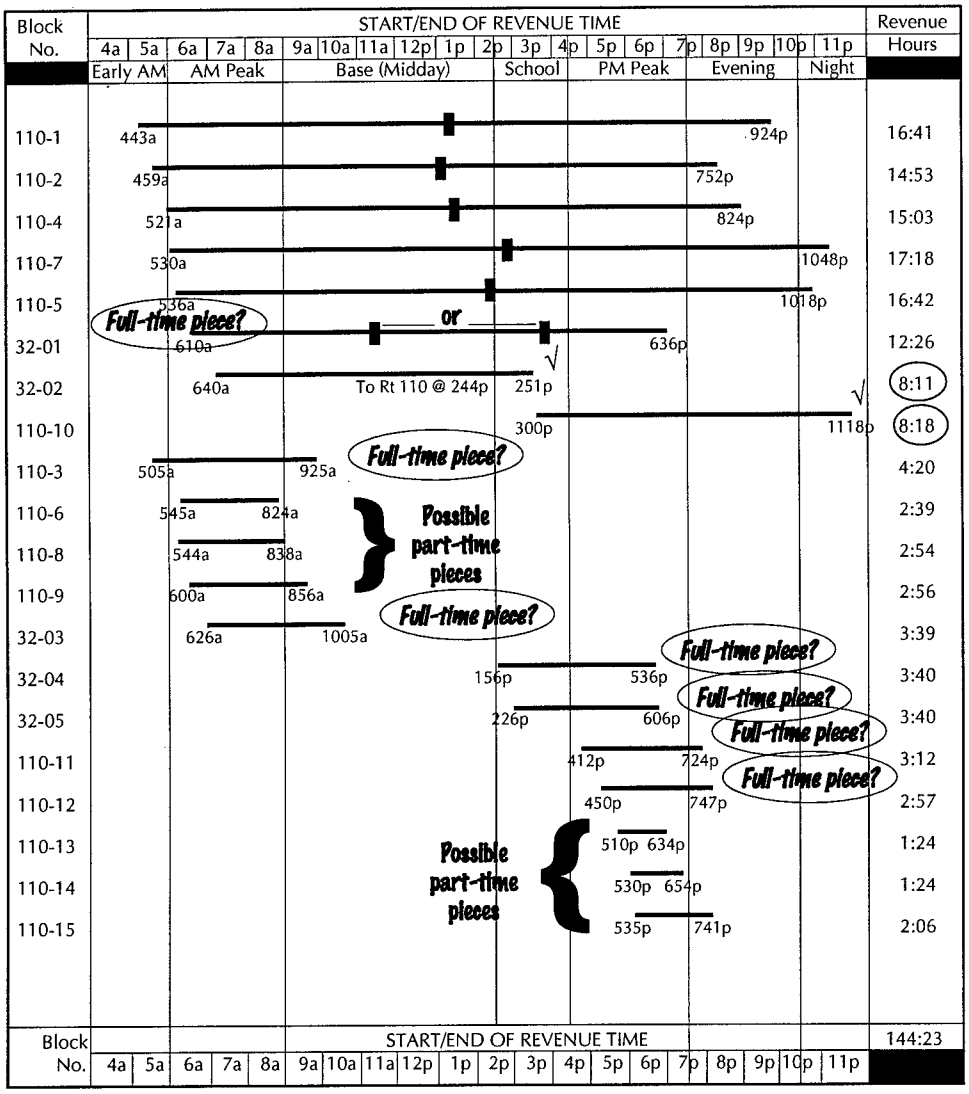
Observations

1) There are six base blocks (110-1, 110-2, 110-4, 110-7, 110-5 and 32-01), five of which could cut into two straight runs each.

2) One base block (32-01) could cut into one straight run with a leftover piece on either end.

3) Two blocks (32-02 and 110-10) are natural straights. These could be cut into straight runs with no leftover pieces.

4) There are five A.M. pieces (110-3, 110-6, 110-8, 110-9 and 32-03) – six if block 32-01 is cut to leave an A.M. piece. These pieces range in revenue time from 2:39 to 4:20.



Block Graph for Route 32 and Route 110 with Scheduler's Notes

5) There are seven P.M. pieces (32-04, 32-05, 110-11, 110-12, 110-13, 110-14 and 110-15). These pieces range in time from 1:24 to 3:40.

Since blocks 110-13, 110-14 and 110-15 range in revenue time from 1:24 to 2:06, they will not easily combine with existing A.M. pieces to make full-time split runs. Therefore, they could be considered for part-time runs. This leaves four P.M. block pieces as candidates for full-time split runs.

Of the A.M. pieces, blocks 110-6, 110-8 and 110-9 look like possible part-time split run pieces. Blocks 110-3 and 32-03 look like possible full-time split run pieces. At this point in the runcut analysis, the scheduler lacks two A.M. pieces of sufficient length to combine with the two remaining P.M. pieces to make full-time split runs. The blocks are therefore not balanced in such a way as to produce a runcut with no pieces left over.

Agencies vary in their approachs to left over pieces. Some stipulate that no pieces be left over while others have no such requirement. This agency has established an objective of achieving piece balance.

One option identified earlier would result in an additional A.M. tripper piece. Block 32-01, with revenue time of 12:26 is not long enough to cut into two runs. Cutting that block into a straight P.M. run with an A.M. tripper piece left over would leave the scheduler short just one A.M. piece.

The final A.M. piece could possibly be cut from Block 110-7. This block is 17:18 in length. If two straight runs were cut from this block – when pull-out, pull-in, relief and other collateral times were added – the runs could approach 9 hours each. A viable option would be to cut this block into two straight runs (an A.M. and a P.M. run) of something less than 8 hours each with a third piece (from the middle) that could qualify as a A.M. piece and combine with a remaining P.M. piece to form a full-time split run.

C. Chronological block listing

	AM Block # / Pull-out	Platform/ Relief or Pull-in	Relief Location		Relief Location	PM Block # / Pull-out	Platform/ Relief or Pull-in
	110-1					110-1	
	4:36a						9:31p
	110-2					110-2	
	4:52a						7:59p
	110-4					110-4	
	5:14a						8:31p
	110-7					110-7	
	5:18a						10:55p
	110-5					110-5	
	5:29a						10:25P
	32-01					32-01	
	6:00a						6:46p
	32-02	8:46				110-10	8:37
	6:30a	3:16p				2:48p	11:25p
	110-3	4:34				32-04	4:00
	4:58a	9:32a				1:46p	5:46p
	110-8	3:13				32-05	4:00
	5:32a	8:45a				2:16p	6:16p
	110-6	2:53				110-13	1:43
	5:38a	8:31a				5:03p	6:46p
	110-9	3:15				110-14	1:43
	5:48a	9:03a				5:23p	7:06p
	32-03	3:59				110-11	3:31
	6:16a	10:15a				4:05p	7:36p
						110-15	2:25
						5:28p	7:53p
						110-12	3:11
						4:43p	7:54p
	AM Platform					PM Platform	

Chronological block listing for Route 32 and Route 110

The runcut process can be facilitated by arranging the blocks into a chronological block listing. In particular, this arrangement helps the scheduler develop split runs that conform to spread limitations.

This form lists base blocks first in chronological pull-out order. All A.M. blocks that pull out prior to noon are also listed in chronological pull-out order. All P.M. tripper blocks that pull out after 12:00 noon are listed in chronological pull-in order to facilitate matching.

Note that while the block graph denotes revenue service start and stop times, the chronological block listing uses pull-out and pull-in times obtained from the block summary recap.

Total platform hours are not yet computed pending the cutting of the base blocks.

VI. The Runcut

A. Achieving piece balance

From the block pool, the scheduler originally estimated four full-time P.M. split pieces (32-04, 32-05, 110-11 and 110-12) and two full-time A.M. split pieces (110-3 and 32-03). The scheduler now investigates two possibilities for gaining the two additional balancing A.M. pieces – from Block 32-01 and Block 110-7.

Opportunity 1 - Block 32-01

Block 32-01 is currently operating from 6:10 a.m. to 6:46 p.m. The scheduler notes that a straight P.M. run of approximately 8 hours ending at 6:46 p.m. would have to begin around 10:46 a.m. To accomplish this break efficiently, the master schedule is examined for an eligible relief time along the route around 10:46 a.m. A relief is possible at Rio Grande & Montano at 10:40 a.m.

Block #	Comanche & Big Sky	Comanche & Wyoming	Comanche & San Mateo	Comanche & Carlisle	N. 4th & Griegos	Rio Grande & Montano		Rio Grande & Montano	N. 4th & Griegos	Comanche & Carlisle	Comanche & San Mateo	Comanche & Wyoming	Comanche & Big Sky
32-01								6:10	6:17	6:27	6:32	6:40	6:50
32-02								6:40	6:47	6:57	7:03	7:10	7:20
32-03	6:26	6:36	6:43	6:49	6:58	7:05	A	7:10	7:17	7:27	7:33	7:40	7:50
32-01	6:56	7:06	7:13	7:19	7:28	7:35	M	7:40	7:47	7:57	8:03	8:10	8:20
32-02	7:26	7:36	7:43	7:49	7:58	8:05		8:10	8:17	8:27	8:33	8:40	8:50
32-03	7:56	8:06	8:13	8:19	8:28	8:35		8:40	8:47	8:57	9:03	9:10	9:20
32-01	8:26	8:36	8:43	8:49	8:58	9:05		9:10	9:17	9:27	9:33	9:40	9:50
32-02	8:56	9:06	9:13	9:19	9:28	9:35		9:40	9:47	9:57	10:03	10:10	10:20
32-03	9:26	9:36	9:43	9:49	9:58	10:05							
32-01	9:56	10:06	10:13	10:19	10:28	10:35		10:40	10:47	10:57	11:01	11:07	11:16
32-02	10:26	10:35	10:41	10:45	10:55	11:02		11:40	11:47	11:57	12:01	12:07	12:15
32-01	11:26	11:35	11:41	11:45	11:55	12:02		12:40	12:47	12:57	1:01	1:07	1:16
32-02	12:26	12:35	12:41	12:45	12:55	1:02		1:40	1:47	1:58	2:04	2:10	2:20
32-01	1:26	1:36	1:42	1:49	1:58	2:06		2:10	2:17	2:28	2:34	2:40	2:50
32-04	1:56	2:06	2:12	2:19	2:28	2:36	P	2:40	2:47	2:58	3:04	3:10	3:20
32-02	2:26	2:36	2:42	2:49	2:58	3:06	M	3:10	3:17	3:28	3:34	3:40	3:50
32-01	2:56	3:06	3:12	3:19	3:28	3:36		3:40	3:47	3:58	4:04	4:10	4:20
32-04	3:26	3:36	3:42	3:49	3:58	4:06		4:10	4:17	4:28	4:34	4:40	4:50
32-02	3:56	4:06	4:12	4:19	4:28	4:36		4:40	4:47	4:58	5:04	5;10	5:20
32-01	4:26	4:36	4:42	4:49	4:58	5:06		5:10	5:17	5:28	5:34	5:40	5:50
32-04	4:56	5:06	5:12	5:19	5:28	5:36							
32-02	5:26	5:36	5:42	5:49	5:58	6:06							
32-01	5:56	6:06	6:12	6:19	6:28	6:36							

Master schedule for Route 32

However, a relief at Comanche & Big Sky at 11:16 a.m. appears more attractive for the following reasons. First, when pull-out, allowances and other collaterals are added, a run beginning service at 10:40 a.m. and ending at 6:46 p.m. will have over 8 hours of pay time, resulting in overtime. Secondly, the block pool contains several shorter P.M. tripper pieces. This would allow the leftover A.M. piece from Block 32-01 to be slightly larger if combined with a shorter P.M. piece.

Breaking the block at 11:16 a.m. at Comanche & Big Sky would result in a P.M. straight of 7:30 platform with an A.M. tripper piece leftover of 5:16 platform. Therefore, the decision is made to break Block 32-01 at Comanche & Big Sky at 11:16 a.m.

Opportunity 2 - Block 110-7

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-7	5:18A	DVC	5:30A	10:48P	CON	10:55P	17:18	17:37

Block 110-7 currently pulls out at 5:18 a.m. and pulls in at 10:55 p.m. The assumption is that a straight A.M. run and a straight P.M. run can be cut with a third early afternoon piece leftover. This third piece could possibly match with an existing P.M. piece, combining for the final full-time split run.

Cutting blocks in the middle of trips is desirable only at field relief locations or at points where extended dwells are scheduled.

The earliest possible relief that can result in a straight A.M. run appears to be eastbound trip arrival 34E at CON at 12:42 p.m. A cut made here would result in an A.M. straight run with revenue service of 7:12 (from 5:30 a.m. to 12:42 p.m.) and platform of 7:24 (5:18 a.m. to 12:42 p.m.).

Trip #	Block #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
34E	110-7	P	12:25	12:36	12:42	12:45	12:53	12:58		1:02	1:09	

Working backwards, the scheduler looks for a P.M. straight run relief location approximately 7.5 hours before the pull-in time of 10:55 p.m. Westbound trip 40W, if cut at arr. CON at 3:23 p.m. yields a P.M. straight run of 7:32 platform (3:23 p.m. to 10:55 p.m.).

Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
40W	110-7	P		2:54	3:03		3:07	3:13	3:23	3:25	3:30	3:43

The remaining piece of Block 110-7 is now 12:42 p.m. to 3:23 p.m. with a platform time of 2:41. Even at 2:41, this piece could match with a number of P.M. pieces.

At this point in the process, the scheduler has achieved piece balance. The next step is to revise the chronological block listing to reflect these changes.

The scheduler notes the relief locations for 110-7 and 32-01 in the relief location column.

	AM Block # / Pull-out	Platform/ Relief or Pull-in	Relief Location		Relief Location	PM Block # / Pull-out	Platform/ Relief or Pull-in
	110-1					110-1	
	4:36a						9:31p
	110-2					110-2	
	4:52a						7:59p
	110-4					110-4	
	5:14a						8:31p
	110-7	**7:24**				**110-7**	**7:32**
	5:18a	**12:42p**	**Arr CON**		**Arr CON**	**3:23p**	**10:55p**
	110-5					110-5	
	5:29a						10:25P
						32-01	**7:30**
					Arr CBS	**11:16a**	**6:46p**
	32-02	8:46				110-10	8:37
	6:30a	3:16p				2:48p	11:25p
	110-3	4:34				32-04	4:00
	4:58a	9:32a				1:46p	5:46p
	110-8	3:13				32-05	4:00
	5:32a	8:45a				2:16p	6:16p
	110-6	2:53				110-13	1:43
	5:38a	8:31a				5:03p	6:46p
	110-9	3:15				110-14	1:43
	5:48a	9:03a				5:23p	7:06p
	32-01	**5:16**				110-11	3:31
	6:00a	**11:16a**	**Arr CBS**			4:05p	7:36p
	32-03	3:59				110-15	2:25
	6:16a	10:15a				5:28p	7:53p
	110-7	**2:41**				110-12	3:11
	12:42p	**3:23p**	**Arr CON**			4:43p	7:54p
	AM Platform					PM Platform	

The chronological block listing is revised to reflect the most recent changes

B. Cutting remaining straight runs

After cutting Block 110-7, base blocks 110-1, 110-2, 110-4 and 110-5 remain. The scheduler seeks to split each block into two runs of nearly equal platform length. In addition, for Route 110 blocks, it is deemed desirable to make as many reliefs near CON as possible as this location is nearest to the vehicle storage facility and will result in the least amount of relief allowance.

Block 110-1: The optimal relief for Block 110-1 is found on eastbound trip 35E at 1:02 p.m. at CON. This cut yields two straight runs of 8:26 platform (4:36 a.m. to 1:02 p.m.) and 8:29 platform (1:02 p.m. to 9:31 p.m.).

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-1	4:36A	CON	4:43A	9:24A	CON	9:31P	16:41	16:55

Trip #	Block #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
35E	110-1	M	12:45	12:56	(1:02)	1:05	1:13	1:18			1:21	1:29

Block 110-2: If this block were cut at 12:38 p.m. at CON on westbound trip 31W, an A.M. straight of 7:46 platform (4:52 a.m. to 12:38 p.m.) and a P.M. straight of 7:21 platform (12:38 p.m. to 7:59 p.m.) would result.

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-2	4:52A	CON	4:59A	7:52P	CON	7:59P	14:53	15:07

Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
31W	110-2	K		12:10		12:19	12:23	12:29	(12:38)	12:40	12:45	12:57

Block 110-4: Cutting this block at 12:58 p.m. at CON on westbound trip 32W would result in an A.M. straight of 7:44 platform (5:14 a.m. to 12:58 p.m.) and a P.M. straight of 7:33 platform (12:58 p.m. to 8:31 p.m.).

BLOCK NO.	PULL-OUT TIME	PULL-ON LOCATION	FIRST REVENUE TIME	LAST REVENUE TIME	PULL-OFF LOCATION	PULL-IN TIME	REVENUE HOURS	PLATFORM HOURS
110-4	5:14A	CON	5:21A	8:24P	CON	8:31P	15:03	15:17

Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
32W	110-4	M	12:29	12:40			12:43	12:49	(12:58)	1:00	1:05	1:17

The chronological block listing is revised to reflect the most recent cuts and platform hours are totalled since all blocks containing required reliefs have now been cut.

	AM Block # / Pull-out	Platform/ Relief or Pull-in	Relief Location		Relief Location	PM Block # / Pull-out	Platform/ Relief or Pull-in
	110-1	**8:26**				**110-1**	**8:29**
	4:36a	**1:02p**	**Arr CON**		**Arr CON**	**1:02p**	**9:31p**
	110-2	**7:46**				**110-2**	**7:21**
	4:52a	**12:38a**	**Arr CON**		**Arr CON**	**12:38a**	**7:59p**
	110-4	**7:44**				**110-4**	**7:33**
	5:14a	**12:58p**	**Arr CON**		**Arr CON**	**12:58p**	**8:31p**
	110-7	7:24				110-7	7:32
	5:18a	12:42p	Arr CON		Arr CON	3:23p	10:55p
	110-5	**8:33**				**110-5**	**8:23**
	5:29a	**2:02p**	**Arr CON**		**Arr CON**	**2:02p**	**10:25p**
						32-01	7:30
					Arr CBS	11:16a	6:46p
	32-02	8:46				110-10	8:37
	6:30a	3:16p				2:48p	11:25p
	110-3	4:34				32-04	4:00
	4:58a	9:32a				1:46p	5:46p
	110-8	3:13				32-05	4:00
	5:32a	8:45a				2:16p	6:16p
	110-6	2:53				110-13	1:43
	5:38a	8:31a				5:03p	6:46p
	110-9	3:15				110-14	1:43
	5:48a	9:03a				5:23p	7:06p
	32-01	5:16				110-11	3:31
	6:00a	11:16a	Arr CBS			4:05p	7:36p
	32-03	3:59				110-15	2:25
	6:16a	10:15a				5:28p	7:53p
	110-7	2:41				110-12	3:11
	12:42p	3:23p	Arr CON			4:43p	7:54p
	AM Platform					PM Platform	

The chronological block listing is revised again to reflect changes.

1) Reconciling platform hours

It is advisable to cross check the total platform hours tallied on the chronological block listing with the total platform hours displayed on the block summary recap. If an error has occurred, the platform totals will differ. In this case, the chronological block listing shows 74:30 A.M. platform hours and 75:58 P.M. platform hours – a total of 150:28. This total is the same as the total shown on the block summary recap.

C. Cutting split runs

The chronological block listing displays the seven A.M. and seven P.M. pieces the scheduler has configured. With an objective of combining these pieces in a manner that minimizes spread time, spread penalty, make-up time and overtime, the scheduler begins cutting split runs.

Observation: Several short pieces exists. These pieces are prime candidates for part-time split runs (runs of less than 6 hours platform). The work rules do, however, limit part-time split runs to no more than 20% of full-time runs.

By listing A.M. pieces in chronological pull-out order and P.M. pieces in chronological pull-in order, the chronological block listing provides a convenient method of viewing and tracking potential A.M. and P.M. pairing combinations that would result in the least amount of average spread time per run. Additionally, if the scheduler begins by pairing A.M. and P.M. pieces of least spread time first, once maximum spread is reached on a given pairing, all potential pairings below that pair on the chronological block listing will also exceed the spread limit.

The process begins by identifying the first piece to be paired. This can be either an A.M. piece or a P.M. piece, depending on preference. For example purposes, the first piece will be Block 110-3, pulling out at 4:58 a.m. and containing platform time of 4:34.

Computing Maximum Pull-in Time:

The spread limitation is 14.5 hours with spread penalty imposed at > 12:00. Spread includes report and turn-in allowances of 10 minutes and 5 minutes, respectively (see Work Rules Summary). Block 110-3 with a pull-out time of 4:58 a.m. reports at 4:48 a.m.. Adding 14.5 hours to the 4:48 report time yields a spread limitation of 7:18 p.m. (including the 5 minute turn-in allowance). Therefore, the paired P.M. piece cannot pull-in later than 7:13 p.m.

Report Time (Pull-out Time minus 10 minutes Report Allowance)	4:48a
Maximum Spread Limitation (Report Time plus 14.5 hours)	7:18p
Maximum Pull-in for Legal Pairing (Maximum Spread minus 5 minutes Turn-in Allowance)	7:13p

Formula for computing maximum spread time

Four P.M. pairing possibilities for 110-3 are identified – Blocks 32-04, 32-05, 110-13 and 110-14. Block 32-04 is chosen to pair with Block 110-3 (see chronological block listing below) because it results in the least amount of spread time – although it does result in 8:34 platform time. A tracking notation "a" is made next to each block to show the pairing.

The next block in order is 110-8, pulling out at 5:32 a.m. with platform time of 3:13. Maximum pull-in time is computed using the spread limitation formula.

Report Time (Pull-out Time minus 10 minutes Report Allowance)	5:22a
Maximum Spread Limitation (Report Time plus 14.5 hours)	7:52p
Maximum Pull-in for Legal Pairing (Maximum Spread minus 5 minutes Turn-in Allowance)	7:47p

Block 32-05 satisfies both the spread limitation and the platform requirement for a full-time split run. Both pieces are annotated with the letter "b."

Block 110-6, paired with Block 110-13 would meet the spread requirement with a total platform of 4:36. This would qualify as a part-time split run. This run is annotated with the letters "c-pt."

Combining Blocks 110-9 and 110-14 also qualifies as a part-time run with a platform time of 4:58 (noted as "d-pt" below).

	AM Block # / Pull-out	Platform/ Relief or Pull-in	Relief Location		Relief Location	PM Block # / Pull-out	Platform/ Relief or Pull-in
a	110-3	4:34		a		32-04	4:00
	4:58a	9:32a				1:46p	5:46p
b	110-8	3:13		b		32-05	4:00
	5:32a	8:45a				2:16p	6:16p
c-pt	110-6	2:53		c-pt		110-13	1:43
	5:38a	8:31a				5:03p	6:46p
d-pt	110-9	3:15		d-pt		110-14	1:43
	5:48a	9:03a				5:23p	7:06p
	32-01	5:16				110-11	3:31
	6:00a	11:16a	Arr CBS			4:05p	7:36p
	32-03	3:59				110-15	2:25
	6:16a	10:15a				5:28p	7:53p
	110-7	2:41				110-12	3:11
	12:42p	3:23p	Arr CON			4:43p	7:54p

The chronological block listing is annotated with the run possibilities.

The next A.M. tripper piece is Block 32-01, pulling out at 6:00 a.m. with 5:16 platform time. The maximum pull-in time for pairing with Block 32-01 is computed as follows.

Report Time (Pull-out Time minus 10 minutes Report Allowance)	5:50a
Maximum Spread Limitation (Report Time plus 14.5 hours)	8:20p
Maximum Pull-in for Legal Pairing (Maximum Spread minus 5 minutes Turn-in Allowance)	8:15p

Although Block 110-11 satisfies the spread, the pairing results in total platform time of 8:47. However, a pairing with the next eligible block, 110-15 results in a combined platform of 7:41. This pairing, with less overtime, is deemed more acceptable and noted as "e."

Maximum pull-in time for Block 32-03 is computed.

Report Time (Pull-out Time minus 10 minutes Report Allowance)	6:06a
Maximum Spread Limitation (Report Time plus 14.5 hours)	8:36p
Maximum Pull-in for Legal Pairing (Maximum Spread minus 5 minutes Turn-in Allowance)	8:31p

Block 110-11 is still available, combining for a platform time of 7:30. This combination is noted as "f." Only one combination of blocks remains. Combining Blocks 110-7 and 110-12 results in a final part-time split run of 5:52 platform time, annotated as "g-pt" below.

	AM Block # / Pull-out	Platform/ Relief or Pull-in	Relief Location		Relief Location	PM Block # / Pull-out	Platform/ Relief or Pull-in
a	110-3	4:34		a		32-04	4:00
	4:58a	9:32a				1:46p	5:46p
b	110-8	3:13		b		32-05	4:00
	5:32a	8:45a				2:16p	6:16p
c-pt	110-6	2:53		c-pt		110-13	1:43
	5:38a	8:31a				5:03p	6:46p
d-pt	110-9	3:15		d-pt		110-14	1:43
	5:48a	9:03a				5:23p	7:06p
e	32-01	5:16		f		110-11	3:31
	6:00a	11:16a	Arr CBS			4:05p	7:36p
f	32-03	3:59		e		110-15	2:25
	6:16a	10:15a				5:28p	7:53p
g-pt	110-7	2:41		g-pt		110-12	3:11
	12:42p	3:23p	Arr CON			4:43p	7:54p

The chronological block listing is again updated.

All the blocks have been cut into runs. The next step is to post the runs to the Run Guide and "cost" the runs.

D. Listing runs on the Run Guide

Run Guides list runs sequentially and provide key cost and other data that are especially helpful in the rostering process where weekly run packages are matched with operators (see Chapter 5). As with other aspects of the scheduling process, the format for the Run Guides vary from system to system. The primary purpose for Run Guides is to present information in an easy to understand and useful format–especially helpful to operators when they select their runs. Many electronic spreadsheets provide presentation formats that can be used to serve that purpose well.

An example Run Guide format is shown below.

RUN GUIDE

Service Day: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	P-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	P-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances				Work Hours	Over-time	Spread Penalty	Pay Hours
															Report	Turn-in	Relief	Make-up				
Totals													Plat-form		Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
															Allowances							

An example Run Guide format

The following column descriptions are provided.

Run No.	Runs are numbered sequentially, beginning with the number 1.
1st Piece	Both the block number and the route number are displayed.
Time On	If the run begins at the garage, this reflects the pull-out time minus the 10-minute report allowance. If the run begins with a street relief, this column reflects the street relief time minus the report allowance minus the relief allowance.
Pull-out/ Relief	If the vehicle pulls out from the garage, the pull-out column reflects the time the vehicle is to pull out of the garage facility. If an on-street relief is made, this reflects the time on route the operator makes the relief.
Pull-in/ Relief	If the vehicle pulls into the garage, the pull-in time is the time the vehicle is to pull into the garage. If a street relief is made, this reflects the time on route the operator gets relieved.
Time Off	For runs ending at the garage, this reflects the pull-in time plus the 5-minute turn-in allowance. If the run ends with a street relief, this reflects the ending time at the relief point plus the relief allowance plus the 5 minute turn-in allowance.
Platform	Platform time is the time from pull-out to pull-in, totalled for one or more pieces.
Total Spread	The total spread is the total elapsed time from the first time on for a run to the last time off for that run, straight or split.
Report Allowance	The report allowance is 10 minutes for each piece that reports to the garage. The report allowance is 5 minutes for each piece that starts at a street relief location.
Turn-in Allowance	All runs receive a 5-minute turn-in allowance.
Relief Allowance	Relief allowances are computed by adding the approximate deadhead time to the relief point plus one-half of the headway at the relief point at the time of the relief.
Make-up Allowance	If platform time and all allowances total less than 8:00, make-up time represents the difference needed to total 8:00. It is often referred to as making the run "whole."
Work Hours	Work hours equal the sum of the platform hours plus all allowances.
Overtime	An amount equal to one half of the work hours over 8:00 is placed in the overtime column.
Spread Penalty	One-half of all minutes (at straight time) over 12:00 for full-time runs: 13:00 for part-time runs.
Pay Hours	The total of work hours plus the larger of overtime or spread penalty.

A common convention for listing runs on the Run Guide is to use chronological pull-out order beginning with full-time straight A.M. runs, continuing with full-time P.M. straight runs, followed by full-time split runs and ending with part-time split runs. Also, to avoid confusion between A.M. and P.M. times when shown in standard time formats, many agencies use the "military" time method, which displays times in a 24-hour clock format. A conversion chart is shown below.

12 hour	24 hour	12 hour	24 hour	12 hour	24 hour
1:00 a.m.	0100	9:00 a.m.	0900	5:00 p.m.	1700
2:00 a.m.	0200	10:00 a.m.	1000	6:00 p.m.	1800
3:00 a.m.	0300	11:00 a.m.	1100	7:00 p.m.	1900
4:00 a.m.	0400	Noon	1200	8:00 p.m.	2000
5:00 a.m.	0500	1:00 p.m.	1300	9:00 p.m.	2100
6:00 a.m.	0600	2:00 p.m.	1400	10:00 p.m.	2200
7:00 a.m.	0700	3:00 p.m.	1500	11:00 p.m.	2300
8:00 a.m.	0800	4:00 p.m.	1600	Midnight	2400

Standard time converted to military time

1) Recording A.M. straight runs

For Routes 110 and 32, (see the Run Guide on the next page) the first A.M. full-time run begins with Block 110-1. This will be Run 1, with a time on of 0426 (10 minutes before pull-out).

Since Run 1 ends with a street relief at 1302 at CON (see chronological block listing), **time off** is computed as relief time (1302) plus relief allowance [time allowed to deadhead from CON to the garage of 7 minutes (obtained from the block summary recap) plus one-half of the 20-minute headway at the time of relief (obtained from the master schedule)] plus the 5-minute turn-in allowance. 1302 + :07 + :10 + :05 = 1324. Since this run consists of one block, the second set of columns is left blank. The next step is to cost the run.

2) Costing A.M. straight runs

Since Run 1 is an A.M. straight run, the platform time is the elapsed time between the pull-out/ relief column and the pull-in/relief column. Platform time is commonly thought of as the time an operator is behind the wheel. In this case, 1302 minus 0436 is 8:26.

Total spread is the elapsed time between time on and time off. 1324 minus 0426 is 8:58.

Report allowance is 10 minutes because this run reports to the garage. All runs receive a 5-minute turn-in allowance. The relief allowance, (computed above) consists of 17 minutes.

Since the platform time of Run 1 is 8:26, no make-up allowance is recorded.

Work hours are the sum of the platform hours plus all allowances. 8:26 plus :10 plus :05 plus :17 equals 8:58. One-half of the work hours over 8:00 is placed in the overtime column. For Run 1, 58/2 = 29. No spread penalty is applicable when spread times does not exceed 12 hours (13 for part-time runs).

Pay hours are the sum of work hours plus overtime or spread penalty. Run 1 pay hours are 9:27.

3) Listing and costing P.M. straight runs

The process for listing and costing P.M. straight runs is nearly identical to the process for listing and costing A.M. runs, except that these runs are not listed chronologically in the chronological block listing because each of the base blocks has one or more reliefs used to create the P.M. straights. Sort order for P.M. straights tends to be agency specific.

Notes for P.M. straight listings:

Run numbers: P.M. straights will be run numbered sequentially beginning with Run 7.

Street reliefs: Runs that begin with street reliefs have a 5-minute report allowance plus the relief allowance.

Block 32-01: This run has a 40-minute relief allowance consisting of a 10-minute deadhead allowance from the garage to CBS plus a 30-minute relief allowance (because the headway is 60 minutes at the relief time and location). Time on for this block is the pull-out/relief time minus the 40-minute relief allowance minus the 5-minute report allowance for runs beginning with a street relief.

The Run Guide below lists the A.M. and P.M. straight runs.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
1	110-1	110	0426	0436	1302	1324							8:26	8:58	:10	:05	:17		8:58	:29		9:27
2	110-2	110	0442	0452	1238	1300							7:46	8:18	:10	:05	:17		8:18	:09		8:27
3	110-4	110	0504	0514	1258	1320							7:44	8:16	:10	:05	:17		8:16	:08		8:24
4	110-7	110	0508	0518	1242	1304							7:24	7:56	:10	:05	:17	:04	8:00			8:00
5	110-5	110	0519	0529	1402	1424							8:33	9:05	:10	:05	:17		9:05	:33		9:38
6	32-02	32/110	0620	0630	1516	1521							8:46	9:01	:10	:05			9:01	:31		9:32
7	32-01	32	1031	1116	1846	1851							7:30	8:20	:05	:05	:40		8:20	:10		8:30
8	110-2	110	1216	1238	1959	2004							7:21	7:48	:05	:05	:17	:12	8:00			8:00
9	110-4	110	1236	1258	2031	2036							7:33	8:00	:05	:05	:17		8:00			8:00
10	110-1	110	1240	1302	2131	2136							8:29	8:56	:05	:05	:17		8:56	:28		9:24
11	110-5	110	1340	1402	2225	2230							8:23	8:50	:05	:05	:17		8:50	:25		9:15
12	110-10	110	1438	1448	2325	2330							8:37	8:52	:10	:05			8:52	:26		9:18
13	110-7	110	1501	1523	2255	2300							7:32	7:59	:05	:05	:17	:01	8:00			8:00

A.M. and P.M. straight runs listed and costed on the Run Guide

4) Listing and costing full-time split runs

Although the process for listing and costing full-time split runs is also similar, several differences do exist, including the inclusion of the second set of columns to cover the second piece of work. Other areas of note include

The platform column reflects the total platform of both run pieces.

The total spread column reflects the total elapsed time between the time on of the first piece to the time off of the second piece.

The report and relief columns reflect the totals of these two allowances that are associated with the two run pieces. The turn-in allowance reflects only the one time per run allowance of 5 minutes. The make-up column reflects any make-up time associated with the complete run, not each piece of the run.

A large split run can contain both overtime and spread penalty. At this agency, only the larger of the two is paid. Both overtime and spread penalty will be calculated and shown in their respective columns when applicable. However, only the larger of the two will be included in the total pay hours.

5) Listing and costing part-time split runs

Areas of note for part-time split runs:

Make-up time is not required for part-time runs.

Overtime does not apply because part-time runs seldom exceed 8 hours.

Spread penalty begins after 13:00 hours instead of 12:00.

The final step in the listing and costing process is to include the part-time split runs and to total the platform, allowance and pay hours columns.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME SPLIT RUNS																						
14	110-3	110	0448	0458	0932	0932	32-04	32	1316	1346	1746	1751	8:34	13:03	:20	:05			8:59	:30	:31	9:30
15	110-8	110	0522	0532	0845	0845	32-05	32	1406	1416	1816	1821	7:13	12:59	:20	:05		:22	8:00		:29	8:29
16	32-01	32	0550	0600	1116	1156	110-15	110	1718	1728	1953	1958	7:41	14:08	:20	:05	:40		8:46	:23	1:04	9:50
17	32-03	110	0606	0616	1015	1015	110-11	110	1555	1605	1936	1941	7:30	13:45	:20	:05		:05	8:00		:47	8:47
PART-TIME SPLIT RUNS																						
18	110-6	110	0528	0538	0831	0831	110-13	110	1653	1703	1846	1851	4:36	13:23	:20	:05			5:01		:11	5:12
19	110-9	110	0538	0548	0903	0903	110-14	110	1713	1723	1906	1911	4:58	1333	:20	:05			5:23		:16	5:39
20	110-7	110	1220	1242	1523	1540	110-12	110	1633	1643	1954	1959	5:52	7:39	:15	:05	:34		6:46			6:46

Part-time split runs are listed and costed.

It is a good idea to check off each run piece on the chronological block listing when the run piece is posted to the Run Guide. This helps to ensure that double posting does not occur and that all run pieces are used.

When all run pieces are posted, the scheduler checks that the total platform hours computed on the Run Guide match the total platform hours on the block summary recap. Any discrepancy indicates an error has occurred somewhere in the process. The Run Guide is completed as shown below. Note: Overtime for runs 14 and 16 are not included in the overtime or pay hour totals.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
1	110-1	110	0426	0436	1302	1324							8:26	8:58	:10	:05	:17		8:58	:29		9:27
2	110-2	110	0442	0452	1238	1300							7:46	8:18	:10	:05	:17		8:18	:09		8:27
3	110-4	110	0504	0514	1258	1320							7:44	8:16	:10	:05	:17		8:16	:08		8:24
4	110-7	110	0508	0518	1242	1304							7:24	7:56	:10	:05	:17	:04	8:00			8:00
5	110-5	110	0519	0529	1402	1424							8:33	9:05	:10	:05	:17		9:05	:33		9:38
6	32-02	32/110	0620	0630	1516	1521							8:46	9:01	:10	:05			9:01	:31		9:32
7	32-01	32	1031	1116	1846	1851							7:30	8:20	:05	:05	:40		8:20	:10		8:30
8	110-2	110	1216	1238	1959	2004							7:21	7:48	:05	:05	:17	:12	8:00			8:00
9	110-4	110	1236	1258	2031	2036							7:33	8:00	:05	:05	:17		8:00			8:00
10	110-1	110	1240	1302	2131	2136							8:29	8:56	:05	:05	:17		8:56	:28		9:24
11	110-5	110	1340	1402	2225	2230							8:23	8:50	:05	:05	:17		8:50	:25		9:15
12	110-10	110	1438	1448	2325	2330							8:37	8:52	:10	:05			8:52	:26		9:18
13	110-7	110	1501	1523	2255	2300							7:32	7:59	:05	:05	:17	:01	8:00			8:00
FULL-TIME SPLIT RUNS																						
14	110-3	110	0448	0458	0932	0932	32-04	32	1316	1346	1746	1751	8:34	13:03	:20	:05			8:59	:30	:31	9:30
15	110-8	110	0522	0532	0845	0845	32-05	32	1406	1416	1816	1821	7:13	12:59	:20	:05		:22	8:00		:29	8:29
16	32-01	32	0550	0600	1116	1156	110-15	110	1718	1728	1953	1958	7:41	14:08	:20	:05	:40		8:46	:23	1:04	9:50
17	32-03	110	0606	0616	1015	1015	110-11	110	1555	1605	1936	1941	7:30	13:45	:20	:05		:05	8:00		:47	8:47
PART-TIME SPLIT RUNS																						
18	110-6	110	0528	0538	0831	0831	110-13	110	1653	1703	1846	1851	4:36	13:23	:20	:05			5:01		:11	5:12
19	110-9	110	0538	0548	0903	0903	110-14	110	1713	1723	1906	1911	4:58	1333	:20	:05			5:23		:16	5:39
20	110-7	110	1220	1242	1523	1540	110-12	110	1633	1643	1954	1959	5:52	7:39	:15	:05	:34		6:46			6:46
													150:28		**3:55**	**1:40**	**4:44**	**:44**	**161:31**	**3:19**	**3:18**	**168:08**
Totals													Plat-form		Report	Turn-in	Relief	Make-up Allowances	Work Hours	Over-time	Spread Penalty	Pay Hours

The completed Run Guide for Routes 110 and 32

The total platform does agree with the block summary recap. This is confirmation that all platform hours have been accounted for. The next step is to check for a measure of runcut efficiency.

VII. Pay to Platform Hours Comparison

One way to measure the efficiency of the runcut is to compute the ratios between pay and platform hours. Both figures can be obtained from the Run Guide and the ratio between them can be computed in either of two ways:

1) Pay Hours / Platform Hours or 2) Platform Hours / Pay Hours

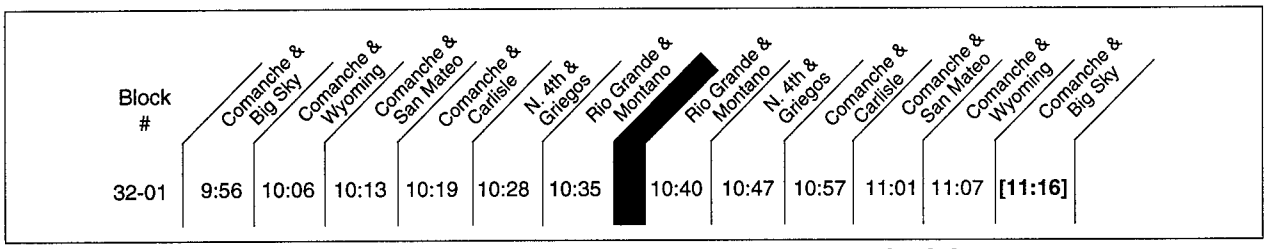
From the Run Guide for Routes 110 and 32, the computations are as follows:
(note that minutes have been converted to decimal equivalents)

1) 168.13 / 150.47 = 1.117 or 2) 150.47 / 168.13 = .895

This means that for every hour of platform time, it takes 1.117 pay hours to put that service on the street. Conversely, it states that every platform hour constitutes 89.5% of a pay hour. This measure of efficiency can be useful when comparing various runcut possibilities.

VIII. Notations of Street Reliefs on Master Schedules

Street reliefs are often annotated on master schedules by placing parentheses around the relief location. One reason for doing this is to provide relief point times and locations for street supervisors who are checking on-street performance. Relief notations are shown below.



Relief points [ ] noted on Route 32 master schedule

Trip #	Block #	Via	Lv DVC	CLD	Arr CON	Lv CON	CLT	CLA	CKP	MYV	Arr WAS	Arr MCC
34E	110-7	P	12:25	12:36	**[12:42]**	12:45	12:53	12:58		1:02	1:09	
35E	110-1	M	12:45	12:56	**[1:02]**	1:05	1:13	1:18			1:21	1:29
36E	110-2	K	1:05	1:16	1:22	1:25	1:33	1:38	1:42		1:49	
37E	110-4	P	1:25	1:36	1:42	1:45	1:53	1:58		2:02	2:09	
38E	110-5	M	1:45	1:56	**[2:02]**	2:05	2:13	2:18			2:21	2:29

Relief points [ ] noted on Route 110 eastbound master schedule

Trip #	Block #	Via	Lv MCC	Lv WAS	MYV	CKP	CLA	CLT	Arr CON	Lv CON	FRY	Arr DVC
31W	110-2	K		12:10		12:19	12:23	12:29	**[12:38]**	12:40	12:45	12:57
32W	110-4	M	12:29	12:40			12:43	12:49	**[12:58]**	1:00	1:05	1:17
40W	110-7	P		2:54	3:03		3:07	3:13	**[3:23]**	3:25	3:30	3:43

Relief points [ ] noted on Route 110 westbound master schedule

CHAPTER 4: EXERCISES

- Prepare a Route 110 Saturday runcut. Use the same work rules and stipulations applied to the weekday runcut (see pg. 102 for a summary of these rules).

RUN GUIDE

Service Days: Route 110 Saturday Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
201 110-1																						
FULL-TIME SPLIT RUNS																						
Totals													Plat-form		Report	Turn-in	Relief	Make-up Allowances	Work Hours	Over-time	Spread Penalty	Pay Hours

CHAPTER 4: EXERCISE ANSWER SHEET

Route 110 Saturday Runcut

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
201	110-1	110	6:22	6:32	14:15	14:42								7:43	8:20	:10	:05	:22		8:20	:10	8:30
202	110-2	110	6:38	6:48	14:45	15:12								7:57	8:34	:10	:05	:22		8:34	:17	8:51
203	110-3	110	7:08	7:18	14:19	14:46								7:01	7:38	:10	:05	:22	:22	8:00		8:00
204	110-4	110	10:24	10:51	19:35	19:40								8:44	9:16	:05	:05	:22		9:16	:38	9:54
205	110-1	110	13:48	14:15	22:22	22:27								8:07	8:39	:05	:05	:22		8:39	:19	8:58
206	110-3	110	13:52	14:19	22:10	22:15								7:51	8:23	:05	:05	:22		8:23	:11	8:34
FULL-TIME SPLIT RUNS																						
207	110-4	110	7:38	7:48	10:51	11:13	110-2	110	14:18	14:45	19:39	19:44		7:57	12:06	:15	:05	:44		9:01	:31	:03	9:32
																			60:13	**2:06**	**:03**	**62:19**
Totals													**Plat-form**		**Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**
															Allowances							

The completed Run Guide for Saturday Route 110

CHAPTER 5

ROSTERING

Advanced Section

I. Introduction

Rostering is the process of grouping daily operator run assignments into weekly run packages or rosters. Weekly roster mixes could include the following

- weekday runs only
- weekday runs and a Saturday run
- weekday runs and a Sunday run
- weekday runs and a Saturday run and a Sunday run

Part-time runs and trippers (open pieces) are sometimes rostered into weekly assignments.

Weekly rosters can consist of five daily eight (8) hour runs; four daily ten (10) hour runs; a combination of eight (8) and ten (10) hour runs; and weekly part-time rosters.

Rostering is generally heavily influenced by work rules, agency policy and past precedent; however it is generally done in one of two formats: operator developed or agency developed.

II. Operator Developed Rostering

With operator developed rostering (sometimes called "cafeteria" rostering), operators choose their weekly roster work from the master days off and daily run lists or some derivative of these lists. The mechanics of how operators actually choose runs and days off, and the forms used, varies widely among agencies, however, the order of the pick is generally based on operator seniority.

A common formula for computing the number of available days off by days of the week for 8-hour runs (5-day work week) is shown below.

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]		5	
Saturdays		1	
Sundays		1	
Weekly Total			
Total Operators [Weekly total divided by 5 days of work per operator]			

Day Off Distribution:

	Total Operators	Minus Daily Runs	Operators Off Each Day
Weekdays [M - F]			[M,T,W,T,F]
Saturdays			
Sundays			
Total [Weekday x 5 plus Saturday plus Sunday]			

Check:

Total Off Days Required - [Total Operators x 2 days]
Total Off Days Assigned - [Sum of Operators Off Each Day]
Leftover Days

Operators required and days off for 8-hour runs (5-day work week)

A. Routes 110 and 32 - no days off on weekdays

Applying this formula to Routes 110 and 32 yields the following result.

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]	20	5	100
Saturdays	0	0	0
Sundays	0	0	0
Weekly Total			100
Total Operators [Weekly total divided by 5 days of work per operator]			20

Day Off Distribution:

	Total Operators	Minus Daily Runs	Operators Off Each Day
Weekdays [M - F]	20	20	[M,T,W,T,F] 0
Saturdays	20	0	20
Sundays	20	0	20
Total [Weekday x 5 plus Saturday plus Sunday]			40

Check:

Total Off Days Required - [Total Operators x 2 days]	40
Total Off Days Assigned - [Sum of Operators Off Each Day]	40
Leftover Days	0

Computing days off for Routes 110 and 32

Since these routes do not operate on Saturday and Sunday, operators have no choice but to take Saturday and Sunday as days off.

The most straight forward operator rostering would likely result in a list of weekly rosters that includes the same run for each operator Monday through Friday. In this example, there would be 17 full-time rosters and 3 part-time rosters.

An example of this weekly roster appears on the following page.

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	1 9:27	1 9:27	1 9:27	1 9:27	1 9:27	Off	47:15
2	Run No. Pay Hours	Off	2 8:27	2 8:27	2 8:27	2 8:27	2 8:27	Off	42:15
3	Run No. Pay Hours	Off	3 8:24	3 8:24	3 8:24	3 8:24	3 8:24	Off	42:00
4	Run No. Pay Hours	Off	4 8:00	4 8:00	4 8:00	4 8:00	4 8:00	Off	40:00
5	Run No. Pay Hours	Off	5 9:38	5 9:38	5 9:38	5 9:38	5 9:38	Off	48:10
6	Run No. Pay Hours	Off	6 9:32	6 9:32	6 9:32	6 9:32	6 9:32	Off	47:40
7	Run No. Pay Hours	Off	7 8:30	7 8:30	7 8:30	7 8:30	7 8:30	Off	42:30
8	Run No. Pay Hours	Off	8 8:00	8 8:00	8 8:00	8 8:00	8 8:00	Off	40:00
9	Run No. Pay Hours	Off	9 8:00	9 8:00	9 8:00	9 8:00	9 8:00	Off	40:00
10	Run No. Pay Hours	Off	10 9:24	10 9:24	10 9:24	10 9:24	10 9:24	Off	47:00
11	Run No. Pay Hours	Off	11 9:15	11 9:15	11 9:15	11 9:15	11 9:15	Off	46:15
12	Run No. Pay Hours	Off	12 9:18	12 9:18	12 9:18	12 9:18	12 9:18	Off	46:30
13	Run No. Pay Hours	Off	13 8:00	13 8:00	13 8:00	13 8:00	13 8:00	Off	40:00
14	Run No. Pay Hours	Off	14 9:30	14 9:30	14 9:30	14 9:30	14 9:30	Off	47:30
15	Run No. Pay Hours	Off	15 8:29	15 8:29	15 8:29	15 8:29	15 8:29	Off	42:25
16	Run No. Pay Hours	Off	16 9:50	16 9:50	16 9:50	16 9:50	16 9:50	Off	49:10
17	Run No. Pay Hours	Off	17 8:47	17 8:47	17 8:47	17 8:47	17 8:47	Off	43:55
						TOTAL FULL-TIME WEEKLY PAY HOURS			**752:35**
PART-TIME RUNS									
18	Run No. Pay Hours	Off	18 5:12	18 5:12	18 5:12	18 5:12	18 5:12	Off	26:00
19	Run No. Pay Hours	Off	19 5:39	19 5:39	19 5:39	19 5:39	19 5:39	Off	28:15
20	Run No. Pay Hours	Off	20 6:46	20 6:46	20 6:46	20 6:46	20 6:46	Off	33:50
						TOTAL PART-TIME WEEKLY PAY HOURS			**88:05**
						TOTAL WEEKLY PAY HOURS			**840:40**

Example roster for same daily run Monday through Friday

B. With Saturday and Sunday runs

The following example illustrates the operator developed rostering approach if Saturday and Sunday runs were part of the process.

Weekday Runs		Saturday Runs		Sunday Runs	
Run No.	Pay Hours	Run No.	Pay Hours	Run No.	Pay Hours
101	8:00	201	8:15	301	8:00
102	8:10	202	8:00	302	8:00
103	8:50	203	8:30		
104	8:35				
105	9:23				

Example run list which includes Saturday and Sunday runs

Day	Number of Daily Runs	X	Weekly Total
Weekdays [M - F]	5	5	25
Saturdays	3	1	3
Sundays	2	1	2
Weekly Total			30
Total Operators [Weekly total divided by 5 days of work per operator]			6

Day Off Distribution:

	Total Operators	Minus Daily Runs	Operators Off Each Day	
Weekdays [M - F]	6	5	[M,T,W,T,F]	1
Saturdays	6	3		3
Sundays	6	2		4
Total [Weekday x 5 plus Saturday plus Sunday]				12

Check:

Total Off Days Required - [Total Operators x 2 days]	12
Total Off Days Assigned - [Sum of Operators Off Each Day]	12
Leftover Days	0

Computing days off with Saturday and Sunday runs

Number of Days Off Allowed						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
4	1	1	1	1	1	3

Available days off for this example

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	105 9:23	105 9:23	105 9:23	105 9:23	105 9:23	Off	46:55
2	Run No. Pay Hours	Off	102 8:10	102 8:10	102 8:10	102 8:10	102 8:10	Off	40:50
3	Run No. Pay Hours	Off	Off	104 8:35	104 8:35	104 8:35	104 8:35	201 8:15	42:35
4	Run No. Pay Hours	302 8:00	103 8:50	Off	Off	103 8:50	103 8:50	203 8:30	43:00
5	Run No. Pay Hours	301 8:00	101 8:00	101 8:00	101 8:00	Off	Off	202 8:00	40:00
6	Run No. Pay Hours	Off	104 8:35	103 8:50	103 8:50	101 8:00	101 8:00	Off	42:15
						TOTAL WEEKLY PAY HOURS			255:35

Example of operator developed weekly roster with weekend runs

When Saturday and Sunday runs are part of the operator developed rostering process, the operators (usually by seniority) also select days off in addition to their daily runs. This example illustrates the tendency of senior operators to select Saturday and Sunday as their days off. Weekly pay hours as well as run start and stop times are among the other factors operators consider when putting their weekly rosters together.

The agency developed rostering approach is illustrated on the following pages.

III. Agency Developed Rostering

With agency developed rostering, the runs are "pre-packaged" into weekly rosters by the agency. The operators, again usually by seniority, pick from this list of weekly rosters.

A number of factors influence how runs are chosen for the weekly rosters. For example, when agencies pay overtime for time worked over 40 hours per week, but do not pay overtime for more than 8 hours work on a given day, an opportunity exists to combine daily runs with greater than 8 hours pay time with daily runs paying less than 8 hours to reduce or eliminate any weekly overtime. The example below illustrates this process.

A. Combining short and long runs

Example
Agency Developed Rostering Option

Objective: To explore rostering options that would combine shorter daily runs with longer daily runs and form weekly run packages that could reduce or eliminate weekly overtime.

Considerations: Daily guarantee is not required.
No daily overtime.
Make-up time to 40 hours per week is required.
Overtime is paid for over 40 hours per week.

Reference: Routes 110 and 32 Run Guide (modified) / Weekly Roster (next 2 pages).

Narrative: In this example, the existing Run Guide for Routes 110 and 32 is modified to reflect the new considerations shown above. Specifically, the daily make-up time is eliminated and the run pay is refigured. Run combinations that would reduce the total amount of required paid overtime are then investigated and recorded on the weekly roster form.

Referring to the newly modified Run Guide for Routes 110 and 32 – Runs 4, 8, 13, 15 and 17 now have no daily make-up time and :44 of previously paid overtime has been eliminated. Runs 4, 8 and 13 (all straight runs) now pay less than 8:00. However, Runs 15 and 17 still exceed 8:00 as a result of the spread penalty.

Runs 4, 8 and 13 could present opportunities to be rostered with runs that pay over 8:00 daily hours and reduce weekly overtime. Of consideration too is the argument that too many different runs for an operator in a work week could present problems.

The resultant weekly roster demonstrates run combinations that have eliminated 3:40 hours of weekly pay time – from 840:40 to 837:00 total pay hours.

The switch day for Runs 3 and 4 is Friday. Friday was chosen because the time off for both runs is fairly close – 13:20 and 13:04. The switch day for Runs 8 and 10 along with Runs 12 and 13 is Monday. Generally, a switch day earlier in the week is preferable. A switch on Friday that results in a later time off is often not found desirable by the operator.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
1	110-1	110	0426	0436	1302	1324							8:26	8:58	:10	:05	:17		8:58	:29		9:27
2	110-2	110	0442	0452	1238	1300							7:46	8:18	:10	:05	:17		8:18	:09		8:27
3	110-4	110	0504	0514	1258	1320							7:44	8:16	:10	:05	:17		8:16	:08		8:24
4	110-7	110	0508	0518	1242	1304							7:24	7:56	:10	:05	:17	~~:04~~	7:56			7:56
5	110-5	110	0519	0529	1402	1424							8:33	9:05	:10	:05	:17		9:05	:33		9:38
6	32-02	32/110	0620	0630	1516	1521							8:46	9:01	:10	:05			9:01	:31		9:32
7	32-01	32	1031	1116	1846	1851							7:30	8:20	:05	:05	:40		8:20	:10		8:30
8	110-2	110	1216	1238	1959	2004							7:21	7:48	:05	:05	:17	~~:12~~	7:48			7:48
9	110-4	110	1236	1258	2031	2036							7:33	8:00	:05	:05	:17		8:00			8:00
10	110-1	110	1240	1302	2131	2136							8:29	8:56	:05	:05	:17		8:56	:28		9:24
11	110-5	110	1340	1402	2225	2230							8:23	8:50	:05	:05	:17		8:50	:25		9:15
12	110-10	110	1438	1448	2325	2330							8:37	8:52	:10	:05			8:52	:26		9:18
13	110-7	110	1501	1523	2255	2300							7:32	7:59	:05	:05	:17	~~:01~~	7:59			7:59
FULL-TIME SPLIT RUNS																						
14	110-3	110	0448	0458	0932	0932	32-04	32	1316	1346	1746	1751	8:34	13:03	:20	:05			8:59	:30	:31	9:30
15	110-8	110	0522	0532	0845	0845	32-05	32	1406	1416	1816	1821	7:13	12:59	:20	:05		~~:22~~	7:38		:29	8:07
16	32-01	32	0550	0600	1116	1156	110-15	110	1718	1728	1953	1958	7:41	14:08	:20	:05	:40		8:46	:23	1:04	9:50
17	32-03	110	0606	0616	1015	1015	110-11	110	1555	1605	1936	1941	7:30	13:45	:20	:05		~~:05~~	7:55		:47	8:42
PART-TIME SPLIT RUNS																						
18	110-6	110	0528	0538	0831	0831	110-13	110	1653	1703	1846	1851	4:36	13:23	:20	:05			5:01		:11	5:12
19	110-9	110	0538	0548	0903	0903	110-14	110	1713	1723	1906	1911	4:58	1333	:20	:05			5:23		:16	5:39
20	110-7	110	1220	1242	1523	1540	110-12	110	1633	1643	1954	1959	5:52	7:39	:15	:05	:34		6:46			6:46
													150:28		**3:55**	**1:40**	**4:44**	**0:00**	**160:47**	**3:19**	**3:18**	**167:24**
Totals													**Plat-form**		**Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**
															Allowances							

The modified Run Guide for Routes 110 and 32

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	1 9:27	1 9:27	1 9:27	1 9:27	1 9:27	Off	47:15
2	Run No. Pay Hours	Off	2 8:27	2 8:27	2 8:27	2 8:27	2 8:27	Off	42:15
3	Run No. Pay Hours	Off	3 8:24	3 8:24	3 8:24	3 8:24	***4*** ***7:56****	Off	***41:32***
4	Run No. Pay Hours	Off	4 ***7:56***	4 ***7:56***	4 ***7:56***	4 ***7:56***	***3*** ***8:24***	Off	***40:08***
5	Run No. Pay Hours	Off	5 9:38	5 9:38	5 9:38	5 9:38	5 9:38	Off	48:10
6	Run No. Pay Hours	Off	6 9:32	6 9:32	6 9:32	6 9:32	6 9:32	Off	47:40
7	Run No. Pay Hours	Off	7 8:30	7 8:30	7 8:30	7 8:30	7 8:30	Off	42:30
8	Run No. Pay Hours	Off	***10*** ***9:24***	8 ***7:48***	8 ***7:48***	8 ***7:48***	8 ***7:48***	Off	***40:36***
9	Run No. Pay Hours	Off	9 8:00	9 8:00	9 8:00	9 8:00	9 8:00	Off	40:00
10	Run No. Pay Hours	Off	***8*** ***7:48***	10 9:24	10 9:24	10 9:24	10 9:24	Off	***45:24***
11	Run No. Pay Hours	Off	11 9:15	11 9:15	11 9:15	11 9:15	11 9:15	Off	46:15
12	Run No. Pay Hours	Off	***13*** ***7:59***	12 9:18	12 9:18	12 9:18	12 9:18	Off	***45:11***
13	Run No. Pay Hours	Off	***12*** ***9:18***	13 ***7:59***	13 ***7:59***	13 ***7:59***	13 ***7:59***	Off	***41:14***
14	Run No. Pay Hours	Off	14 9:30	14 9:30	14 9:30	14 9:30	14 9:30	Off	47:30
15	Run No. Pay Hours	Off	15 ***8:07***	15 ***8:07***	15 ***8:07***	15 ***8:07***	15 ***8:07***	Off	***40:35***
16	Run No. Pay Hours	Off	16 9:50	16 9:50	16 9:50	16 9:50	16 9:50	Off	49:10
17	Run No. Pay Hours	Off	17 ***8:42***	17 ***8:42***	17 ***8:42***	17 ***8:42***	17 ***8:42***	Off	***43:30***
							TOTAL FULL-TIME WEEKLY PAY HOURS		***748:55***
PART-TIME RUNS									
18	Run No. Pay Hours	Off	18 5:12	18 5:12	18 5:12	18 5:12	18 5:12	Off	26:00
19	Run No. Pay Hours	Off	19 5:39	19 5:39	19 5:39	19 5:39	19 5:39	Off	28:15
20	Run No. Pay Hours	Off	20 6:46	20 6:46	20 6:46	20 6:46	20 6:46	Off	33:50
							TOTAL PART-TIME WEEKLY PAY HOURS		**88:05**
* Runs that have changed are denoted in bold italic.							**TOTAL WEEKLY PAY HOURS**		**837:00**

Agency developed weekly roster combining short and long runs

Since mixing shorter runs with longer runs can reduce weekly pay hours where daily guarantees do not exist, the scheduler may want to explore rostering previously classified part-time runs with longer runs. The example below illustrates this option.

B. Considering part-time runs as short full-time runs

Example
Agency Developed Rostering Option

Objective: To reclassify part-time runs as short full-time runs and to investigate run combinations that reduce or minimize weekly overtime.

Considerations: Part-time runs do not exist.
Daily guarantee is not required.
No daily overtime.
Make-up time to 40 hours per week is required.
Overtime is paid for over 40 hours per week.

Reference: Run Guide for Route 110 and 32 (modified) / Weekly Roster (next 2 pages).

Narrative: Runs 18, 19 and 20 have been "reclassified" as full-time runs. Combinations with longer daily runs for weekly rosters are explored and illustrated on the following pages.

At first glance, it would appear that considerable opportunity exists to reduce weekly overtime. However, the run combinations in this example actually result in an increase of 5:00 pay hours per week.

The primary reason for this increase is the spread penalty. For part-time runs, the spread penalty was imposed for spreads over 13 hours. However, for full-time runs the spread penalty is imposed for runs over 12 hours. The total spread penalty for Runs 18 and 19 increased by 30 minutes each. This translates to 1:00 per day or 5:00 for the work week.

Another consideration is the potential diminishing return that can be associated with the extensive mixing of runs. Many agencies would prefer that the operator work the same run daily, whenever possible, for at least the following reasons:

- Customers often prefer the familiarity of the same operator each day.
- Accident risk is minimized when the operator is very familiar with the route.
- Great variability in time on and time off every day may disrupt the operator's "internal clock" and could lead to a greater risk of accidents or incidents.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-In	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
1	110-1	110	0426	0436	1302	1324							8:26	8:58	:10	:05	:17		8:58	:29		9:27
2	110-2	110	0442	0452	1238	1300							7:46	8:18	:10	:05	:17		8:18	:09		8:27
3	110-4	110	0504	0514	1258	1320							7:44	8:16	:10	:05	:17		8:16	:08		8:24
4	110-7	110	0508	0518	1242	1304							7:24	7:56	:10	:05	:17		7:56			7:56
5	110-5	110	0519	0529	1402	1424							8:33	9:05	:10	:05	:17		9:05	:33		9:38
6	32-02	32/110	0620	0630	1516	1521							8:46	9:01	:10	:05			9:01	:31		9:32
7	32-01	32	1031	1116	1846	1851							7:30	8:20	:05	:05	:40		8:20	:10		8:30
8	110-2	110	1216	1238	1959	2004							7:21	7:48	:05	:05	:17		7:48			7:48
9	110-4	110	1236	1258	2031	2036							7:33	8:00	:05	:05	:17		8:00			8:00
10	110-1	110	1240	1302	2131	2136							8:29	8:56	:05	:05	:17		8:56	:28		9:24
11	110-5	110	1340	1402	2225	2230							8:23	8:50	:05	:05	:17		8:50	:25		9:15
12	110-10	110	1438	1448	2325	2330							8:37	8:52	:10	:05			8:52	:26		9:18
13	110-7	110	1501	1523	2255	2300							7:32	7:59	:05	:05	:17		7:59			7:59
FULL-TIME SPLIT RUNS																						
14	110-3	110	0448	0458	0932	0932	32-04	32	1316	1346	1746	1751	8:34	13:03	:20	:05			8:59	:30	:31	9:30
15	110-8	110	0522	0532	0845	0845	32-05	32	1406	1416	1816	1821	7:13	12:59	:20	:05			7:38		:29	8:07
16	32-01	32	0550	0600	1116	1156	110-15	110	1718	1728	1953	1958	7:41	14:08	:20	:05	:40		8:46	:23	1:04	9:50
17	32-03	110	0606	0616	1015	1015	110-11	110	1555	1605	1936	1941	7:30	13:45	:20	:05			7:55		:47	8:42
18	110-6	110	0528	0538	0831	0831	110-13	110	1653	1703	1846	1851	4:36	13:23	:20	:05			5:01		***:41***	***5:42***
19	110-9	110	0538	0548	0903	0903	110-14	110	1713	1723	1906	1911	4:58	1333	:20	:05			5:23		***:46***	***6:09***
20	110-7	110	1220	1242	1523	1540	110-12	110	1633	1643	1954	1959	5:52	7:39	:15	:05	:34		6:46			6:46
													150:28		**3:55**	**1:40**	**4:44**	**0:00**	**160:47**	**3:19**	***4:18***	***168:24***
Totals													**Plat-form**		**Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**
															Allowances							

The modified Run Guide for Routes 110 and 32

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	1 9:27	1 9:27	1 9:27	1 9:27	1 9:27	Off	47:15
2	Run No. Pay Hours	Off	2 8:27	2 8:27	2 8:27	2 8:27	2 8:27	Off	42:15
3	Run No. Pay Hours	Off	3 8:24	3 8:24	3 8:24	3 8:24	***4*** ***7:56***	Off	***41:32***
4	Run No. Pay Hours	Off	4 ***7:56***	4 ***7:56***	4 ***7:56***	4 ***7:56***	***3*** ***8:24***	Off	***40:08***
5	Run No. Pay Hours	Off	***7*** ***8:30***	5 9:38	5 9:38	5 9:38	5 9:38	Off	***40:04***
6	Run No. Pay Hours	Off	6 9:32	6 9:32	6 9:32	6 9:32	6 9:32	Off	47:40
7	Run No. Pay Hours	Off	***19*** ***6:09***	7 8:30	7 8:30	7 8:30	7 8:30	Off	***40:09***
8	Run No. Pay Hours	Off	***10*** ***9:24***	8 ***7:48***	8 ***7:48***	8 ***7:48***	8 ***7:48***	Off	***40:36***
9	Run No. Pay Hours	Off	9 8:00	9 8:00	9 8:00	9 8:00	9 8:00	Off	40:00
10	Run No. Pay Hours	Off	***8*** ***7:48***	10 9:24	10 9:24	10 9:24	10 9:24	Off	***45:24***
11	Run No. Pay Hours	Off	11 9:15	11 9:15	11 9:15	11 9:15	11 9:15	Off	46:15
12	Run No. Pay Hours	Off	***13*** ***7:59***	12 9:18	12 9:18	12 9:18	12 9:18	Off	***45:11***
13	Run No. Pay Hours	Off	***12*** ***9:18***	13 ***7:59***	13 ***7:59***	13 ***7:59***	***20*** ***6:46***	Off	***40:01***
14	Run No. Pay Hours	Off	***18*** ***5:42***	14 9:30	***20*** ***6:46***	14 9:30	14 9:30	Off	***40:58***
15	Run No. Pay Hours	Off	***20*** ***6:46***	***17*** ***8:42***	***17*** ***8:42***	15 ***8:07***	15 ***8:07***	Off	***40:24***
16	Run No. Pay Hours	Off	16 9:50	***18*** ***5:42***	***18*** ***5:42***	16 9:50	16 9:50	Off	***40:54***
17	Run No. Pay Hours	Off	17 ***8:42***	***19*** ***6:09***	***15*** ***8:07***	17 ***8:42***	17 ***8:42***	Off	***40:22***
18	Run No. Pay Hours	Off	***14*** ***9:30***	***16*** ***9:50***	***16*** ***9:50***	***18*** ***5:42***	***18*** ***5:42***	Off	***40:34***
19	Run No. Pay Hours	Off	***15*** ***8:07***	***15*** ***8:07***	19 ***6:09***	***5*** ***9:38***	***5*** ***9:38***	Off	***41:39***
20	Run No. Pay Hours	Off	***5*** ***9:38***	20 6:46	***14*** ***9:30***	20 6:46	***13*** ***7:59***	Off	***40:39***
							TOTAL WEEKLY PAY HOURS		**842:00**

Agency developed weekly roster – no Part-time runs

The development of 4-day rosters is a viable option for many agencies. The ability to convert pay hours from overtime to straight time is the primary agency advantage associated with 4-day rostering. However, a significant portion of any cost savings may or may not be offset by the added cost of hiring and training additional personnel and paying additional fringe benefits.

For many operators, the 4-day roster is a welcomed option because it provides an additional day off per week. The example below illustrates the option of combining 4- and 5-day rosters.

C. Combining four- and five-day rosters

Example
Agency Developed Rostering Option

Objective: To develop both 4-day rosters and 5-day rosters.

Considerations: Part-time runs do exist.
Daily guarantee is required.
Overtime accrues daily.
All runs with daily pay of 9:30 or more can be considered for 4-day rosters.
Overtime is paid for over 40 hours per week.

Reference: Modified Run Guide for Routes 110 and 32 / Weekly Roster (next 2 pages).

Narrative: Runs 5 (9:38), 6 (9:32), 14 (9:30) and 16 (9:50) all pay 9:30 or more. One work day from each of these runs can be assigned to a new 4-day roster, Run 18. This results in five 4-day rosters instead of the previous four 5-day rosters – from 5, 6, 14 and 16 to 5, 6, 14, 16 and 18.

Total equivalent straight time pay hours, however, remains unchanged at 752:35. Part-time rosters and associated pay hours also remain unchanged.

Perhaps the only advantage this particular option brings to the agency for these runs is the benefit of a 4-day workweek for some operators, generally the senior operators who would prefer the 4-day work week.

However, many agencies might avoid the longer work day altogether for fear that the operator's customer performance or safety consciousness could decline.

Depending on the available runs, 4-day rosters can result in a reduction of overtime costs, particularly when daily guarantees are paid.

RUN GUIDE

Service Days: _____ Effective: _____

Run No.	1st Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	2nd Block	Piece Route	Time On	Pull-out /Relief	Pull-in /Relief	Time Off	Plat-form	Total Spread	Allowances Report	Turn-in	Relief	Make-up	Work Hours	Over-time	Spread Penalty	Pay Hours
FULL-TIME STRAIGHT RUNS																						
1	110-1	110	0426	0436	1302	1324							8:26	8:58	:10	:05	:17		8:58	:29		9:27
2	110-2	110	0442	0452	1238	1300							7:46	8:18	:10	:05	:17		8:18	:09		8:27
3	110-4	110	0504	0514	1258	1320							7:44	8:16	:10	:05	:17		8:16	:08		8:24
4	110-7	110	0508	0518	1242	1304							7:24	7:56	:10	:05	:17	:04	8:00			8:00
5	110-5	110	0519	0529	1402	1424							8:33	9:05	:10	:05	:17		9:05	:33		9:38
6	32-02	32/110	0620	0630	1516	1521							8:46	9:01	:10	:05			9:01	:31		9:32
7	32-01	32	1031	1116	1846	1851							7:30	8:20	:05	:05	:40		8:20	:10		8:30
8	110-2	110	1216	1238	1959	2004							7:21	7:48	:05	:05	:17	:12	8:00			8:00
9	110-4	110	1236	1258	2031	2036							7:33	8:00	:05	:05	:17		8:00			8:00
10	110-1	110	1240	1302	2131	2136							8:29	8:56	:05	:05	:17		8:56	:28		9:24
11	110-5	110	1340	1402	2225	2230							8:23	8:50	:05	:05	:17		8:50	:25		9:15
12	110-10	110	1438	1448	2325	2330							8:37	8:52	:10	:05			8:52	:26		9:18
13	110-7	110	1501	1523	2255	2300							7:32	7:59	:05	:05	:17	:01	8:00			8:00
FULL-TIME SPLIT RUNS																						
14	110-3	110	0448	0458	0932	0932	32-04	32	1316	1346	1746	1751	8:34	13:03	:20	:05			8:59	:30	:31	9:30
15	110-8	110	0522	0532	0845	0845	32-05	32	1406	1416	1816	1821	7:13	12:59	:20	:05		:22	8:00		:29	8:29
16	32-01	32	0550	0600	1116	1156	110-15	110	1718	1728	1953	1958	7:41	14:08	:20	:05	:40		8:46	:23	1:04	9:50
17	32-03	110	0606	0616	1015	1015	110-11	110	1555	1605	1936	1941	7:30	13:45	:20	:05		:05	8:00		:47	8:47
PART-TIME SPLIT RUNS																						
18	110-6	110	0528	0538	0831	0831	110-13	110	1653	1703	1846	1851	4:36	13:23	:20	:05			5:01		:11	5:12
19	110-9	110	0538	0548	0903	0903	110-14	110	1713	1723	1906	1911	4:58	1333	:20	:05			5:23		:16	5:39
20	110-7	110	1220	1242	1523	1540	110-12	110	1633	1643	1954	1959	5:52	7:39	:15	:05	:34		6:46			6:46
													150:28		**3:55**	**1:40**	**4:44**	**0:44**	**161:31**	**3:19**	**3:18**	**168:08**
Totals													**Plat-form**		**Report**	**Turn-in**	**Relief**	**Make-up**	**Work Hours**	**Over-time**	**Spread Penalty**	**Pay Hours**
															Allowances							

The Run Guide for Routes 110 and 32

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	1 9:27	1 9:27	1 9:27	1 9:27	1 9:27	Off	47:15
2	Run No. Pay Hours	Off	2 8:27	2 8:27	2 8:27	2 8:27	2 8:27	Off	42:15
3	Run No. Pay Hours	Off	3 8:24	3 8:24	3 8:24	3 8:24	3 8:24	Off	42:00
4	Run No. Pay Hours	Off	4 8:00	4 8:00	4 8:00	4 8:00	4 8:00	Off	40:00
5	Run No. Pay Hours	Off	***Off***	5 9:38	5 9:38	5 9:38	5 9:38	Off	48:10
6	Run No. Pay Hours	Off	6 9:32	***Off***	6 9:32	6 9:32	6 9:32	Off	47:40
7	Run No. Pay Hours	Off	7 8:30	7 8:30	7 8:30	7 8:30	7 8:30	Off	42:30
8	Run No. Pay Hours	Off	8 8:00	8 8:00	8 8:00	8 8:00	8 8:00	Off	40:00
9	Run No. Pay Hours	Off	9 8:00	9 8:00	9 8:00	9 8:00	9 8:00	Off	40:00
10	Run No. Pay Hours	Off	10 9:24	10 9:24	10 9:24	10 9:24	10 9:24	Off	47:00
11	Run No. Pay Hours	Off	11 9:15	11 9:15	11 9:15	11 9:15	11 9:15	Off	46:15
12	Run No. Pay Hours	Off	12 9:18	12 9:18	12 9:18	12 9:18	12 9:18	Off	46:30
13	Run No. Pay Hours	Off	13 8:00	13 8:00	13 8:00	13 8:00	13 8:00	Off	40:00
14	Run No. Pay Hours	Off	14 9:30	14 9:30	***Off***	14 9:30	14 9:30	Off	47:30
15	Run No. Pay Hours	Off	15 8:29	15 8:29	15 8:29	15 8:29	15 8:29	Off	42:25
16	Run No. Pay Hours	Off	16 9:50	16 9:50	16 9:50	***Off***	16 9:50	Off	49:10
17	Run No. Pay Hours	Off	17 8:47	17 8:47	17 8:47	17 8:47	17 8:47	Off	43:55
18	Run No. Pay Hours	Off	***5*** ***9:38***	***6*** ***9:32***	***14*** ***9:30***	***16*** ***9:50***	***Off***	Off	***38:30***
							TOTAL FULL-TIME WEEKLY PAY HOURS		**752:35**
PART-TIME RUNS									
19	Run No. Pay Hours	Off	18 5:12	18 5:12	18 5:12	18 5:12	18 5:12	Off	26:00
20	Run No. Pay Hours	Off	19 5:39	19 5:39	19 5:39	19 5:39	19 5:39	Off	28:15
21	Run No. Pay Hours	Off	20 6:46	20 6:46	20 6:46	20 6:46	20 6:46	Off	33:50
							TOTAL PART-TIME WEEKLY PAY HOURS		**88:05**
							TOTAL WEEKLY PAY HOURS		**840:40**

Agency developed weekly roster combining 4- and 5-day rosters

IV. Rostering Efficiency

A creative scheduler will explore a full range of rostering options, looking for an effective balance between the achievement of cost efficiencies and the provision of comfortable routines for both operators and passengers. Historically, rostering has been a function heavily controlled and influenced by labor agreement, agency policy and past precedent.

Agency developed rostering typically provides more opportunity to explore run mixtures that achieve greater cost efficiencies. However, operator developed rostering has the advantage of providing greater participation and involvement by operators.

As part of the iterative process of schedule making that includes trip generation, blocking and runcutting, rostering can be considered the final step before approved service hits the streets.

CHAPTER 5: EXERCISE

- Roster the Saturday Route 110 runs developed in Chapter 4 with the weekday Route 32 and Route 110 runs. Strive to minimize payroll hours and the mixing of runs.

CHAPTER 5: EXERCISE ANSWER SHEET - Example Roster

Weekly Roster No.		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Weekly Pay Hours
FULL-TIME RUNS									
1	Run No. Pay Hours	Off	1 9:27	1 9:27	1 9:27	1 9:27	1 9:27	Off	47:15
2	Run No. Pay Hours	Off	2 8:27	2 8:27	2 8:27	2 8:27	2 8:27	Off	42:15
3	Run No. Pay Hours	Off	3 8:24	3 8:24	3 8:24	3 8:24	3 8:24	Off	42:00
4	Run No. Pay Hours	Off	Off	4 8:00	4 8:00	4 8:00	4 8:00	201 8:30	40:30
5	Run No. Pay Hours	Off	5 9:38	Off	5 9:38	5 9:38	5 9:38	202 8:51	47:23
6	Run No. Pay Hours	Off	6 9:32	6 9:32	Off	6 9:32	6 9:32	203 8:00	46:08
7	Run No. Pay Hours	Off	7 8:30	7 8:30	7 8:30	7 8:30	7 8:30	Off	42:30
8	Run No. Pay Hours	Off	8 8:00	8 8:00	8 8:00	8 8:00	8 8:00	Off	40:00
9	Run No. Pay Hours	Off	9 8:00	9 8:00	9 8:00	9 8:00	9 8:00	Off	40:00
10	Run No. Pay Hours	Off	10 9:24	10 9:24	10 9:24	Off	10 9:24	205 8:58	46:34
11	Run No. Pay Hours	Off	11 9:15	11 9:15	11 9:15	11 9:15	Off	206 8:34	45:34
12	Run No. Pay Hours	Off	12 9:18	12 9:18	12 9:18	12 9:18	12 9:18	Off	46:30
13	Run No. Pay Hours	Off	13 8:00	13 8:00	13 8:00	13 8:00	13 8:00	Off	40:00
14	Run No. Pay Hours	Off	14 9:30	14 9:30	14 9:30	14 9:30	14 9:30	Off	47:30
15	Run No. Pay Hours	Off	15 8:29	15 8:29	15 8:29	15 8:29	15 8:29	Off	42:25
16	Run No. Pay Hours	Off	16 9:50	16 9:50	16 9:50	16 9:50	16 9:50	Off	49:10
17	Run No. Pay Hours	Off	17 8:47	17 8:47	17 8:47	17 8:47	17 8:47	Off	43:55
Relief 18	Run No. Pay Hours	Off	4 8:00	5 9:38	6 9:32	10 9:24	11 9:15	Off	45:49
						TOTAL FULL-TIME WEEKLY PAY HOURS			**795:28**
PART-TIME RUNS									
19	Run No. Pay Hours	Off	18 5:12	18 5:12	18 5:12	18 5:12	18 5:12	Off	26:00
20	Run No. Pay Hours	Off	19 5:39	19 5:39	19 5:39	19 5:39	19 5:39	Off	28:15
21	Run No. Pay Hours	Off	20 6:46	20 6:46	20 6:46	20 6:46	20 6:46	Off	33:50
						TOTAL PART-TIME WEEKLY PAY HOURS			**88:05**

continued

RUNS TO BE FILLED		
Run No.		204
Pay Hours		9:54
Run No.		207
Pay Hours		9:32
	TOTAL FILL RUN PAY HOURS	19:26
	TOTAL WEEKLY PAY HOURS	902:59

In this solution, five of the seven Saturday runs are combined with weekday full-time runs as shown. The other two, shown as "fill" runs, will typically be operated on the days shown by an extra board operator.

Note that new Run 18 is a relief run. A relief run generally consists of days of work that are left over when weekday runs are combined with runs that work on Saturday and/or Sunday.